EMERGING RENEWABLES PROGRAM SYSTEMS VERIFICATION REPORT 2004-2005

Consultant Report

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ABSTRACT

The California Energy Commission's Emerging Renewables Program (ERP) conducted 165 on-site verifications of small scale renewable energy systems in 2004-2005. These were done to evaluate system performance and to verify whether the documentation and rebate paid were consistent with installed equipment. The ERP has provided incentive funds for the installation of over 15,000 eligible systems (97% PV) with roughly 70 percent installed in 2002-2004. Verification was supported by a mail survey that measured customer experience in applying to the ERP, receiving utility interconnection approval, and helpfulness and knowledge of the retailer and/or installer. This report concludes that instantaneous measurements showed most PV systems were operating in-line with expectations with modest performance losses due to shading and soiling. Overall, applicants were satisfied with the ERP and received the proper rebate amount. However, 16 systems had equipment installed that differed notably from final documentation and would require additional investigation to determine if the correct rebate was paid.

KEYWORDS

The keywords for purposes of a search on the California Energy Commission Web site (www.energy.ca.gov) are as follows:

capacity factor, Emerging Renewables Program, photovoltaic, purchaser experience survey, renewable energy, shading, solar, system performance, system verification, utility interconnection, wind

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EXECUTIVE SUMMARY

With the support of the Emerging Renewables Program (ERP), administered by the California Energy Commission, small-scale solar photovoltaic (PV) system installation has skyrocketed since the California energy crisis. Over 15,000 systems have been installed with the support of the ERP incentive, roughly 70 percent of which have been installed between 2002 and 2004. The developing small-scale solar market has hundreds of installers serving net-metered customers. Overwhelmingly, these customers have purchased roof-mounted, mono- or polycrystalline PV panel systems retrofitted to their existing homes or small businesses. Over half of these systems are in Pacific Gas & Electric's northern California service territory.

Verification Results Summary

This report reviews the results of 165 system verifications conducted in 2004: One hundred and ten from a stratified random sample, 40 pre-selected, and 15 near sample sites and when time permitting. A customer experience survey was also conducted for systems supported by the ERP. This report concludes the following:

- Out of all the verified sites, 47 systems had equipment installed that differed in some respect from the final documentation provided in the rebate claim application. Most differences are considered insignificant; however, 16 would require further investigation to confirm whether information was misrepresented and the appropriate rebate amount paid.

- Of the 16 sites that are in question, seven of them are pre-selected sites. The remaining are from randomly sampled sites. Of all the randomly sampled sites in question, a predominant number was installed by medium installers. Medium installers are ones who have installed between five and 19 sites at the time the sample was developed in early 2004.

- The vast majority of systems verified in this study are operating and most are performing within expected ranges, both on the basis of capacity and energy production. Four systems were partially operating or not at all.

- In the case where performance meter start date is unknown it creates difficulty in determining system output (kWh/time period).

- Of the five sites visited with wind energy systems, only one did not have performance problems or issues of concern.

- The experience level of the installer does not noticeably affect system performance.
- Most customers are highly satisfied with their PV systems.
- Customers state they bought their system to save money on their electric bill, and the ERP rebate was a key factor in their purchase decision.
- The majority of PV customers are also energy-efficiency customers, and have made efficiency investments in their homes.
- Some customers are confused about the term net-metering, did not receive or do not recall the system performance estimate from their vendor, and/or are unfamiliar with the ERP name.
- Most customers report being satisfied with the ERP.

System Performance Metrics

The most relevant performance metrics for utility resource planners interested in integrating PV into their resource portfolios is PV capacity at times of peak demand and annual energy production in kilowatt hours (kWh) so that solar can be counted for resource adequacy purposes.

In this report, 85 percent of sites for which data was collected included a performance meter. These meters collect cumulative energy production in kWh or watt hours (Wh) but do not collect data on system performance during specific periods, for example, the system peak. Instantaneous system performance data were collected at the time of the site visit to assess capacity relative to ambient conditions affecting energy production.

A variety of ratings exist against which to compare actual system performance. As discussed in detail in Chapter 3, the rating a customer sees when purchasing a solar module is based on laboratory Standard Test Conditions (STC.)[1] This level of performance will not be achieved over any sustained period in regular system operations. The Energy Commission uses a different, lower module rating for purposes of calculating the rebate amount, called PVUSA test conditions (PTC,)[2] based on a different set of test conditions, and also takes into account power losses associated with the inverter efficiency. Neither of these rating methods predicts true expected output due to other losses not accounted for in these methodologies. However, both ratings can be adjusted to reflect other losses present in systems. To establish expected instantaneous capacity, current site-specific ambient conditions are measured and adjustments made to the rating. To predict energy production over time requires rating adjustments based on local solar resource, orientation, tilt, shading, and typical ambient conditions.

The performance metrics used in this report compare system performance to STC ratings, but where relevant also include a comparison to the system rated output (kW_{CEC}) used by the Energy Commission to determine rebate payments.

System Performance Results

Peak system conditions in California correlate with high levels of sunlight on summer afternoons. Intense sunlight, or irradiance, also creates strong performance from PV systems; however, high temperatures will slightly reduce system performance. So, although the sun is likely to be shining brightly during periods of peak demand, PV capacity may not be at its optimum during these conditions. The data collected in this study were random in geography, time of day, day of week and level of sunlight. The results show that 70 percent of sites were operating at 63 percent or better of STC rating adjusted for actual irradiance at the time the measurement was taken compared to a 70% benchmark.

Measurements of energy production (kWh) over time were limited to a smaller sample and dependant on customer reported start dates. Overall system capacity factor was 15 percent compared to STC rating and 18 percent compared with rated system output (kWh/kWcec), within the range of 15 to 20 percent generally used in forecasting PV energy production. Where system energy production data was available, roughly 70 percent of systems performed at 90 percent or better of ideal annual energy production (kWh), as calculated by adjusting the STC rating do to site-specific orientation, soiling, and shading issues. The data on which these calculations rely must be viewed as representative rather than precise. In most cases the performance meters are not revenue quality, and the meter start date data are collected as reported by the system owner, who often does not have a solid record of that date.

The overall results from this study suggest that many verified systems are operating within a reasonable tolerance of performance expectations. The results are also consistent with studies performed in California and globally that show a wide range of performance across systems, including a number that perform above expectations. With the addition of the requirements for a performance meter and an estimated energy production on the ERP application form, the Energy Commission has provided customers with the tools to measure and compare their actual and expected system performance. However, an unfortunately large number of systems did not fall within the expected capacity factor. As previously explained, this may be partially due to not knowing the exact start date of the meter readings, but this does not explain all the instances of low indicated performance.

1: INTRODUCTION

In accordance with sections 25740 through 25751 of the California Public Resources Code, the California Energy Commission administers the Emerging Renewables Program (ERP) to stimulate the market for renewable energy systems that supply on-site electricity in California. The ERP targets small renewable energy system purchasers of less than 30 kilowatts (kW) and offers cash rebates for program participants to offset their cost of purchasing emerging renewable energy systems that meet specific criteria. This program aims to accelerate the development of a self-sustaining market for renewable energy technologies.

According to the *Emerging Renewables Program Guidebook*, the Energy Commission may "conduct field inspections to verify systems are operating properly and installed as specified in the reservation request and payment claim applications."[3] The KEMA-XENERGY team was contracted to conduct system verifications.

Verification Objectives

The primary objective of the visits was to verify system compliance with the ERP Guidebook and detect any discrepancies within the verification sample. In addition, due to the modest incremental effort required, data on system performance and customers' program experience were also collected. The performance data provides an indication of the range and average quantities of system capacity and energy production; customer survey responses provide insight on their expectations, motivations and satisfaction. All of these results can inform future ERP Guidebook adjustments.

Table 1-1 shows the three objectives of the verification effort and summarizes the approach in meeting the proposed objectives.

Table 1-1
Project Objectives and Approach

Component	Objective	Approach
System compliance	Verify whether installed systems comply with the ERP Guidebook.	Collect on-site information regarding rebated equipment. Compare against existing ERP database.
System performance	Verify installation quality v. industry standard and collect static and cumulative generation performance.	Measure static data during verification. Collect inception-to-date data for cumulative performance analysis.
Program participants' experience	Collect self-reported information on participants' decision-making process, installation experience and overall program satisfaction.	Collect data via mail-in survey and a brief on-site or phone interview.

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Methodology

Sampling

In January 2004, a verification sample of 237 sites was extracted from the ERP database that was current as of November 2003. This original sample allocation had two components: 40 pre-selected sites specified by the program manager and 110 random sites from a targeted sample frame.

The pre-selected sample consists of three categories:

- A: Pre-selected sites
- B: Pre-selected installers
- C: Pre-selected sellers

A random sample was extracted based on four installer categories:

- I: self-install/unknown installer
- II: commercial installers who have installed one to four sites
- III: commercial installers who have installed five to 19 sites, and
- IV: commercial installers who have installed 20 or more sites.

Sites associated with commercial installers who had installed one to four sites were excluded such that the sample included 19 to 20 installers from each of the three remaining installer categories. The verification sample was drawn from random sites associated with these installers across eight geographic regions and all three investor-owned utility (IOU) territories.

At the end of August 2004, the sample pool was nearly depleted, but 30 sites remained to be scheduled. In addition, the ERP Project Manger requested that KEMA-XENERGY investigate sites installed by a particular installer for which the Energy Commission received multiple customer complaints. To complete the verification work, a second sample was selected to expand the number of sites per installer category in the original sample pool and to add new installers. Details of the sampling plan can be found in Appendix B.

Training

In January 2004, while the original sample was being extracted, six energy specialists were trained for the year-long verification effort. Specialists were trained in the classroom for one day to familiarize them with the ERP, the on-site verification protocols, and the situations to be expected on site. The classroom training was immediately followed by a two-day on-site training where the team test-verified five systems. A Training Manual was written and provided to the team as well.

Scheduling Site Visits

A verifier or scheduler called the customer responsible for a targeted site one week in advance to make an appointment. The schedulers followed a scheduling protocol to determine whether the site could be feasibly scheduled. While scheduling for site visits, two common problems arose: telephone numbers in the database were incorrect/outdated or unavailable. In general, those customers contacted by phone were enthusiastic about a verification visit and were very cooperative.

A flowchart of all customer communications and materials involved are included in Appendix A.

Accomplishments

In 2004, the KEMA-XENERGY team verified 165 photovoltaic and small wind systems. Six categories of data were collected during an on-site visit: confirmation of system specifications, location, characteristics, static data during time of visit, historical performance of the system, and the customer’s participation experience.

Partial data were taken for 25 sites that have limited or no access. A more comprehensive characterization of the verified sites is detailed in Chapter 2, On-Site Results.

A total of 283 customer surveys were provided to PV owners and 170 collected during the course of the verification (see Chapter 2.) Surveys were sent to all customers in the original sample and customers whose systems were installed by the particular pre-selected installer from the second sample. An introduction letter and a prepaid return envelope were included with the survey. All customers visited were contacted three times regarding surveys that were not returned promptly. Customers were first reminded about the survey in the scheduling call and a second time when the verifier was on site. Finally, a follow-up phone call was made in late October or early November.

The survey was designed to obtain information from the customer in the following categories:

- System and program knowledge
- Purchase decision process
- Economics of the system
- Program and installation experience
- Customer's adoption of energy efficiency strategies
- Demographics.

A copy of the customer survey can be found in Appendix A of this report, and results are found in Chapter 3, Customer Survey Results.

2: ON-SITE RESULTS

Completed Sites by Sample Category

The goal of verifying 150 targeted sites was completed with 140 full inspections and 10 limited-access visits. Fifteen additional site verifications were completed due to their proximity to other sites or because there was time available between two scheduled site visits—11 of these additional site visits were limited-access visits. Therefore, 144 on-site verifications and 21 limited-access verifications were completed for a total of 165 sites visited. A total of 27 sites were found to be installed by different installers than the ones indicated in the ERP database. Of these, 11 involved an obvious change in the installer type. The results of these changes are incorporated into this section.[4] **Table 2-1** summarizes the sites completed by installer type, sample pool, and level of verification.

Table 2-1
Completed Sites by Installer Categories, Sample Pool and Level of Verification

Installer Category	Targeted Sites				Additional Sites		
	Goal	Completed	Full	Limited Access	Completed	Full	Limited Access
I	14	15	14	1	0	0	0
II	0	3	3	0	0	0	0
III	54	48	47	1	1	1	0
IV	42	46	42	4	5	2	3
A	19	13	11	2	0	0	0
B	18	22	20	2	9	1	8
C	3	3	3	0	0	0	0
Total: 165	150	150	140	10	15	4	11

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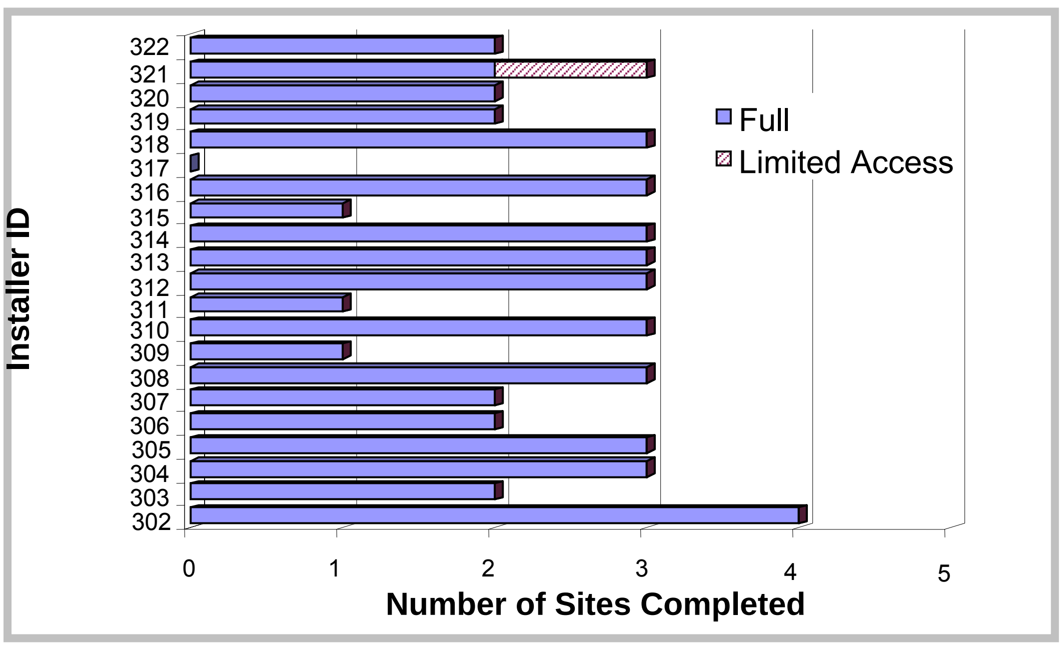
Random Sample

Category I contains owner-installed or unknown installer sites, of which 14 unique self-installed sites and one unknown installer site were verified. Four of the five originally unknown installer sites were identified during the course of verification; one was installed by the owner, one was installed by the seller, and two by commercial installers who had not installed any other system as of the date that the database was used for sample development. Three self-installed sites identified in the database were found to be commercial contractor installations, one by the seller, one by the contractor of the new house, and one by a small commercial installer. Four sites reserved as being installed by commercial installers were found to be owner-installed. All of these sites were reserved before March 3, 2003 when the edition of the ERP Guidebook became effective that reduces the rebate for owner-installed systems.

Categories II, III, and IV consist of installers differentiated by the number of sites they have installed as reported in the database—a proxy for installer experience. Category II installers, the ones with less than four installed sites, were excluded from the verification sample. However, three Category I sites were found to be installed by unique Category II installers.

Category III commercial installers are those who had installed between five and 19 sites. As shown in **Figure 2-1**, 20 unique installers and 49 installations were verified in this category.[5]

Figure 2-1
Verified Sites from Category III Installers by Installer/Seller
(Commercial Installers with 5 to 19 Sites)



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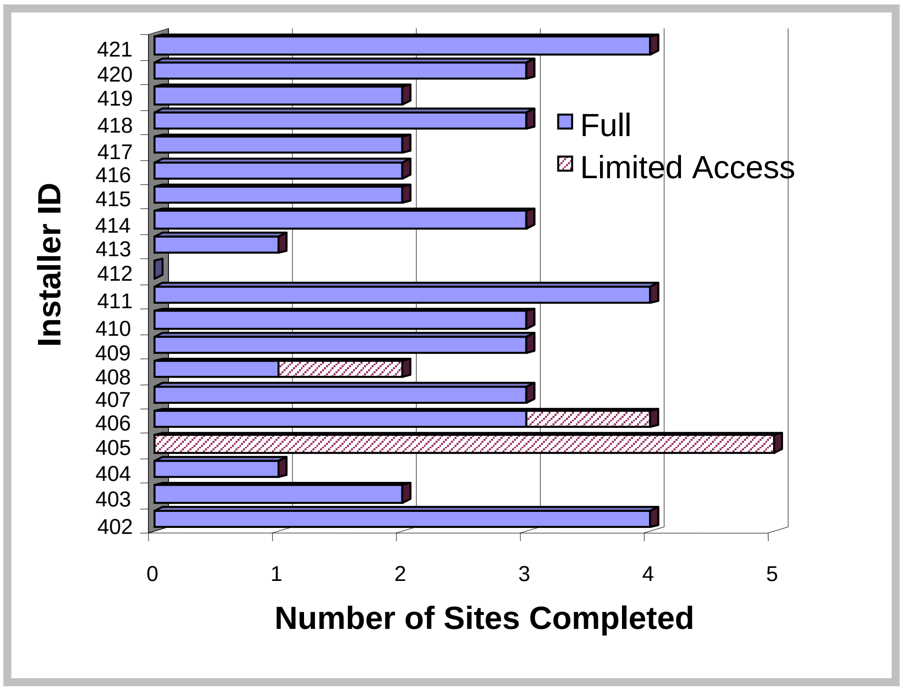
Category IV represents large commercial installers who had installed more than 20 sites. Of this category, 19 unique large installers and 53 installations were verified.[6] The number of installations per installer is summarized in **Figure 2-2**.

Figure 2-2
Verified Sites from Category IV Installers by Installer/Seller
(Commercial Installers with Over 20 Sites)



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Pre-Selected Sample

The rest of the sites were verified under the pre-selected category. These are individual installations, installers, or sellers that were selected by the ERP Project Manager. As shown in **Table 2-2**, 39 sites were completed under this category.

Table 2-2
Installers Verified Under the Pre-selected Sample

Pre-selected Sites by Category	Full	Limited Access
	36	12
A- Unique sites	11	2
B- Installers	22	10
C- Retailers	3	0

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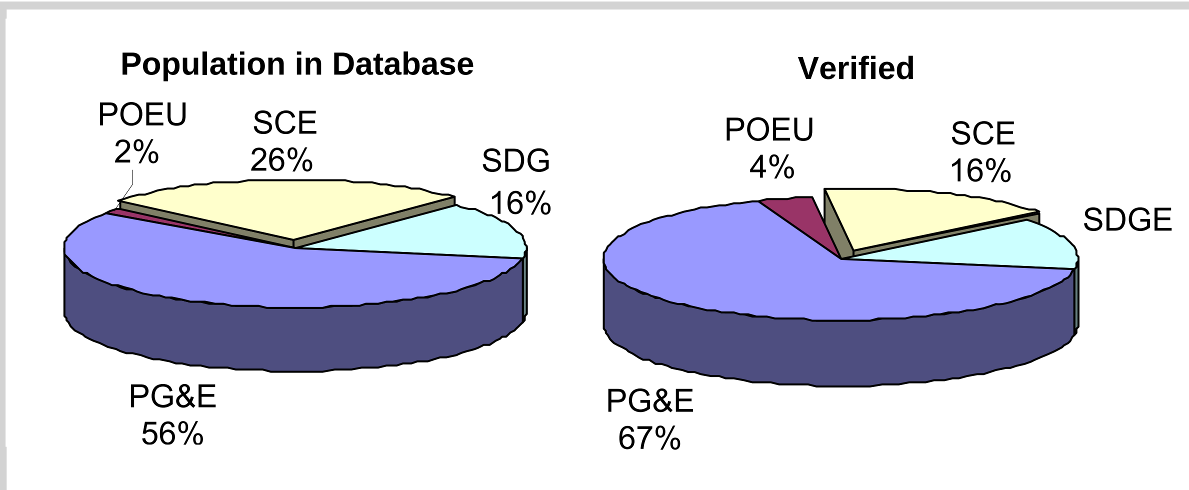
Characteristics of the Verified Systems

Geographic Location

The verified sites were distributed among the three major IOUs: Pacific Gas and Electric (PG&E), Southern California Edison (SCE), San Diego Gas and Electric (SDG&E), and publicly owned electric utilities (POEU) (see **Figure 2-3**)[7]

Figure 2-3
Population and Verified Sites by Utility Category
(N=6925, N=165)



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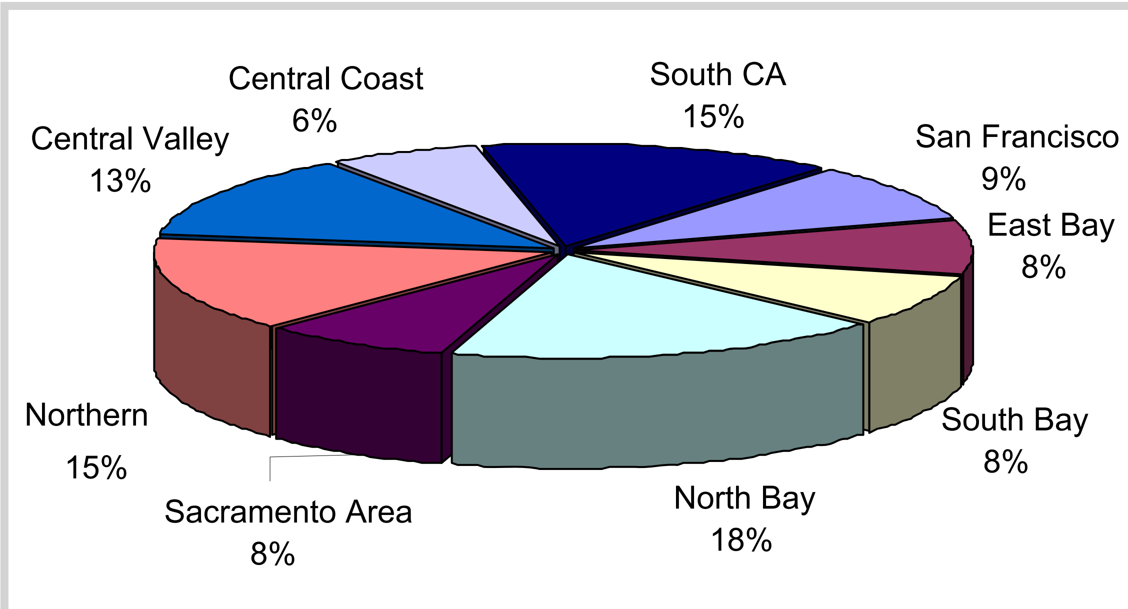
The verified sites were distributed similarly to the database population. Although PG&E and SCE have similar sized customer bases, PG&E had more than twice the number of installations in the database than SCE.

Figure 2-4 shows that the verified sites were geographically diverse. Since PG&E had the majority of installed sites, proportionally more sites were verified in northern California.

Figure 2-4
Verified Sites by Region (N=165)



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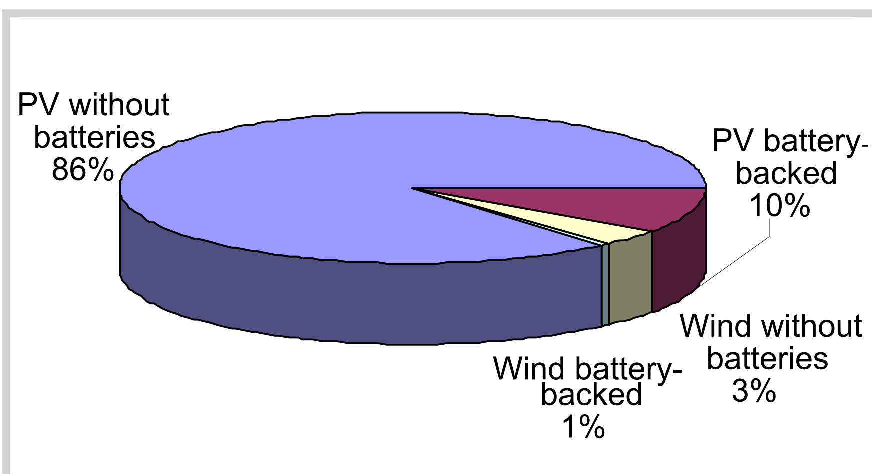
Type of System

As shown in **Figure 2-5**, of the 165 systems verified, five were wind energy systems and the rest were PV. Fifteen systems had battery backup. One of these was a wind system.

Figure 2-5
Type of Verified Systems (N=144)[8]



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As shown in **Figures 2-6** and **2-7**, most of the systems verified were less than five kW (STC) and employ crystalline-silicon modules.

Figure 2-6
Verified PV Sites by System Size (N=134)

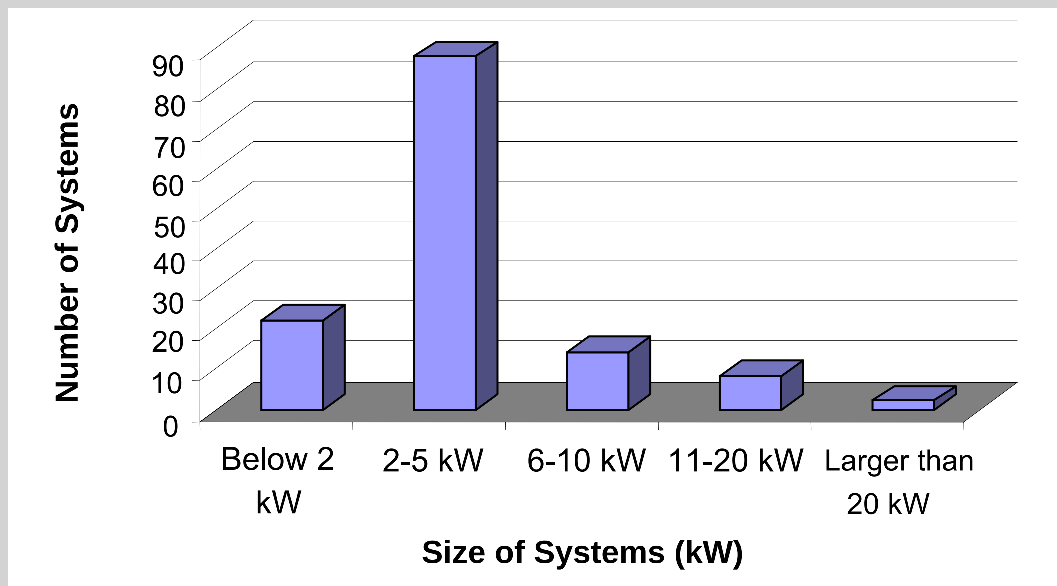

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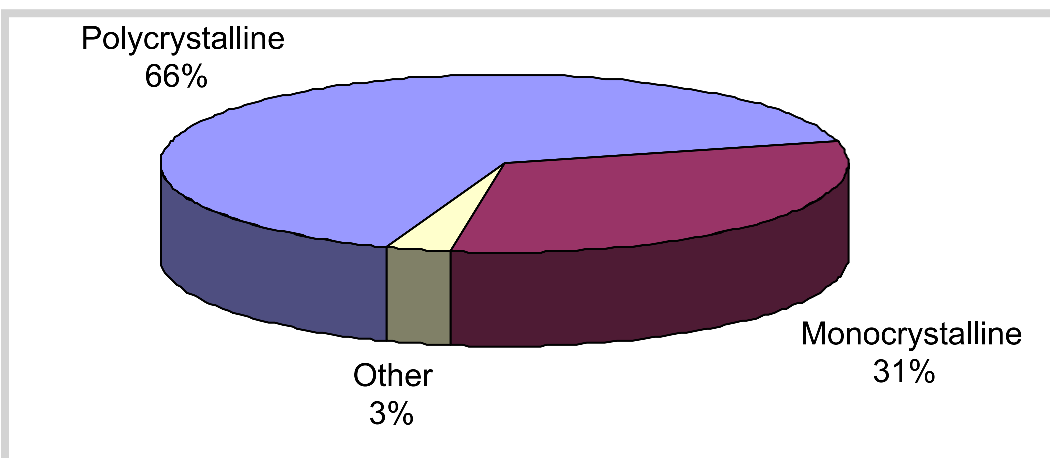
Figure 2-7 shows that 98 percent of the PV systems verified had monocrystalline or polycrystalline silicon modules.[9]

Figure 2-7
Verified PV systems by Module Type (N=139)



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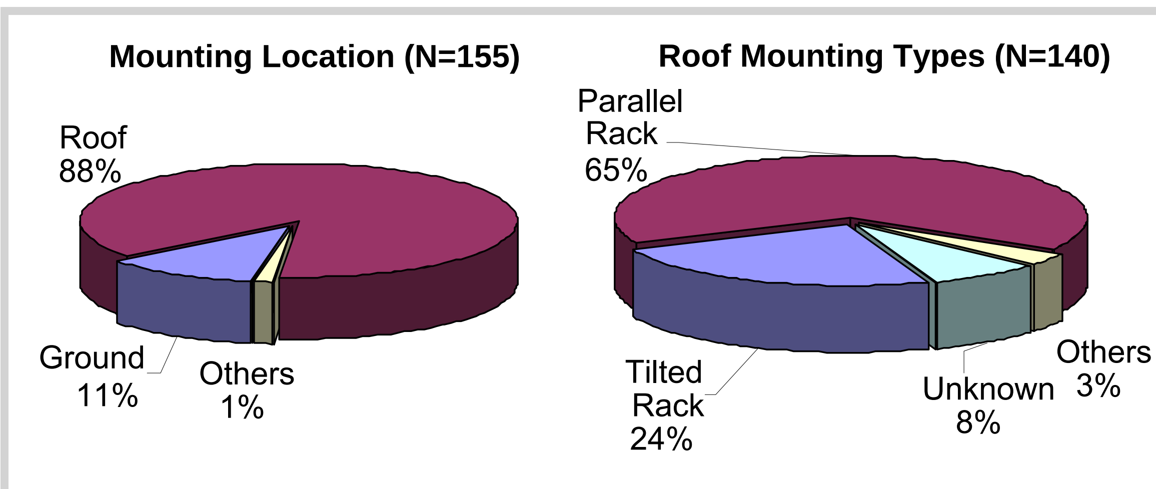
Of the 149 sites that have adequate access, 85 percent have at least one performance meter. A performance meter was required for all system applications approved after March 31, 2003. The sites without a performance meter were reserved and approved prior to that date.

System Siting and Mounting

The bulk of systems verified were roof-mounted (88 percent); most of the remainders (11 percent) were ground-mounted. Two other mounting locations were observed on a gazebo frame (parallel rack) and a hillside (tilted rack).[10]

A parallel rack-mounting structure was used for 65 percent of verified sites, and a tilted rack was used for 24 percent of verified sites.[11] One each of the following other mounting structures were observed: panels bolted to the roof directly, dual-axis tracker, shingle, and trellis mount. The proportion of systems by mounting structure is shown for roof-mounted and ground-mounted systems, respectively in **Figure 2-8**.

Figure 2-8
Verified Sites by Mount Location and Mounting Types



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Ground-mounted systems account for 11 percent of the verified systems. Over half of the ground-mounted systems (55 percent) were mounted on tilted rack. The other types of mounting include pole mount, single-axis tracker, and dual-axis tracker. (**Table 2-3**).

Table 2-3
Verified Ground-Mounted Systems by Mounting Types (N=18)

Ground mounting type	
Tilted rack	10
Pole mount	4
Single-Axis tracker	3
Dual-axis tracker	1

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Shading

Shading can be a significant factor in reducing annual energy output of a PV array. PV systems are often composed of several arrays of multiple modules each. Since cells are connected in series, a single shaded cell can drag down the performance of an array by as much as half in the extreme case.

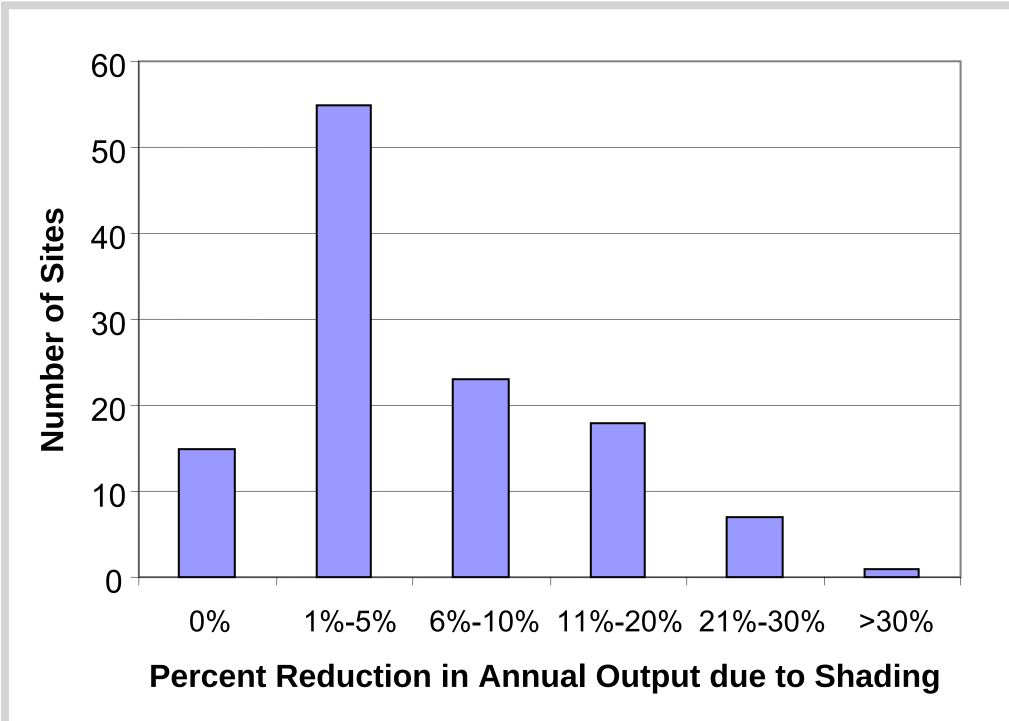
Orientation, tilt angle, and percentage of shading per month were measured on site. A solar pathfinder was used to trace the percentage of shading for each month of the year based on the surrounding obstacles. Data collected were used to estimate the sun-hours (kWh/m^2/day) on a monthly basis using National Renewable Energy Laboratory (NREL) 30-year monthly average solar radiation data.

The following calculation was used to determine the affect of shading:

$$\%\ \text{Output Affected By Shading} = \frac{\left[\sum_{n=\text{January}}^{\text{December}} \left(\frac{100 - \%\ \text{shading}_n}{100}\right) \times \text{number of days}_n \times \text{sun} - \text{hours}_n\right]}{\left[\sum_{n=\text{January}}^{\text{December}} \text{number of days}_n \times \text{sun} - \text{hours}_n\right]}$$

As shown in **Figure 2-9**, systems on average reduce output by seven percent due to shading. Out of 119 sites with data, roughly 15 percent of the verified systems were measured to have no shading, while about 70 percent were measured to have less than five percent reduction in output due to shading. Nine sites were measured with significant shading (over 20 percent reduction in output).

Figure 2-9
Solar Pathfinder Results: Expected Shading Impact on System Output (N=119)[12]



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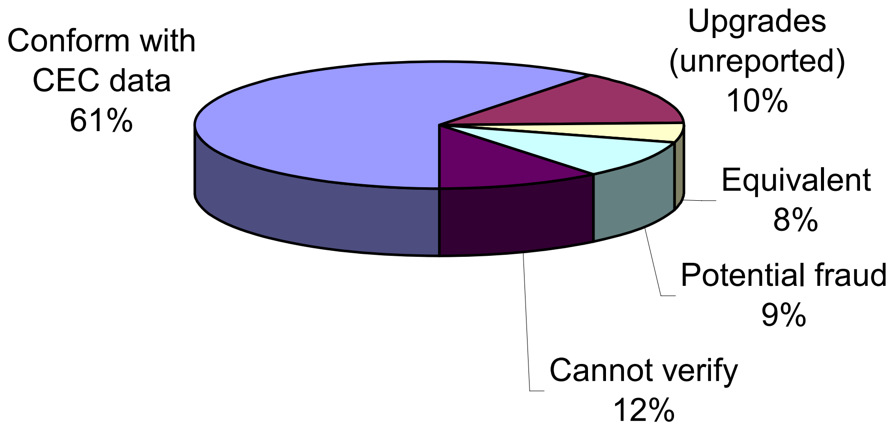
Observed Equipment Incongruities

Of the sites verified, 47 cases were identified in which the equipment observed differed from that listed in the ERP database.[13] **Figure 2-10** shows the entire sample and **Table 2-4** lists the differences between the database and observed equipment by category.

Figure 2-10
Verification Results of Rebated Equipment (N=165 Sites)



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Most cases of equipment discrepancies have impact on system performance. Thirty-six percent of the equipment discrepancies were apparently unreported upgrades, which suggest the rebate could have been underpaid. Thirty-four percent of the equipment discrepancies were system downgrades, which could potentially be overpaid rebates. The rest of the discrepancies (thirty percent) are unreported differences in equipment but had no impact on the system performance.

One of these discrepancies was regarding system location. Although location does not affect system performance, it suggests potential fraud for the following reasons: 1) the site address where the system actually resides also hosts another system and their aggregate system size exceeds the 30 kW program limit, 2) The rebates of the two systems were approved concurrently; however, according to the Guidebook, only one reservation can be made for a site within a nine-month period. It appears that the system owner wanted to take advantage of the ERP rebate for an oversized system before the rebate level went down and therefore, reserved the system under two addresses.

The performance impact of all equipment discrepancies are summarized in the **Table 2-4**.

Table 2-4
Performance Impact Related to Observed Equipment Differences from Database Records

Performance Impact	Difference	Number
Better (17)	Full System upgrade	4
	Increased number of modules	6
	Upgrade in wattage (may decrease number of modules)	5
	Downgrade in wattage, but increased number of modules	1
	Changed make and model number of higher PTC ratings	1
None (14)	Make and model name changes	6
	Inverter upgrade (replacement or warranty)	6
	Downgraded inverter	1
	Changed inverter display	1
Worse (16)	Full System downgrade	4
	Decreased number of modules	7
	Decreased number of modules, but inverter upgrade	2
	Increased wattage per modules, but decreased modules	1
	Ineligible equipment/Location discrepancy	2
	Total Changes:	**47**

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Seventeen of the cases involved were system upgrades. The most common upgrade was an increase in system size, either by adding modules or upgrading the wattage per modules. In some cases, the efficiency and wattage of the equipment were upgraded as well. The additions range from one module to 16 modules. In some cases, a site might have appeared to have a full system upgrade, but further investigations prove that the upgraded systems were reserved under different reservation numbers.

Fourteen cases of equipment incongruities did not affect the expected performance of the rebated systems. Six incongruities were related to name changes to the make and model numbers of PV modules or manufacturer name changes. The systems were observed to be essentially the same unit with the same wattages.

Six of the cases were due to inverter upgrade and all of these were Xantrex inverters. The reservation was made based on the first version of the Sun Tie (ST) inverter. The company later replaced all of these models with better models under warranty and at no cost to their customers. The replacement models included STXR and STRXRUPG. As revealed in our customer questionnaire, five sites received their replacement Xantrex inverters in the summer of 2003 at no cost. One customer replaced his inverters twice and had to pay for it the first time.

One system changed its SunnyBoy Display to remote access. And one system downgraded an inverter to lessen excess inverter capacity - this change did not affect system performance nor rebate level. One system, as mentioned before, had a location discrepancy, but did not have any performance issues.

Fifteen sites were identified with equipment downgraded from their rebated reservations. Of these, seven were installed by medium installers (those who installed between five and 19 systems), representing almost a third of our sampled installers in that category. Pre-selected installers represented seven of the downgraded systems; and one system fell under the owner-installed category.

Further investigation would be necessary to determine if the system downgrades are a result of legitimate changes or if these 16 sites received improper rebate payments.

System Performance

System Performance Introduction

This subsection addresses issues associated with measuring and comparing PV system performance and includes a discussion of:

- System Performance Measurement
- System Performance Data Collection
- System Performance Rating Methods
- Calculating Expected System Generation
- Derated STC Capacity
- PV System Performance Studies and Metrics.

System Performance Measurement

Performance data for on-grid systems has been collected over a decade for research purposes, though substantial California-specific data is available only in the last five years.

Metering of on-grid systems in California has changed over the past few years, and therefore performance measurement of PV systems is improving. Rebate reservations accepted by the Energy Commission after March 31, 2003 are required to have a performance meter that displays the cumulative generation from the PV system (accurate to ± five percent). The Energy Commission maintains a list of eligible meters that fulfill this requirement, but eligible meters are not required to be revenue-quality or utility-grade meters. Revenue-quality meters are subject to measurement standards on which utilities and retail electric service providers bill customers and buy power. Increasingly, customers purchasing PV systems with the support of the Self-Generation Incentives Program (SGIP), begun in 2001, are purchasing revenue-quality meters as a part of their system. This market-based performance metering contrasts with research performance metering paid for by program administrators or government agencies.

Two predominantly relevant performance metrics for utility resource planners interested in integrating PV into their resource portfolios are PV capacity at times of peak demand so that solar can be counted for resource adequacy purposes, in kWoutput/kWrated, and PV annual energy production, in kW-hours (kWh/kWrated).

System Performance Data Collection

In this report, 85 percent of sites for which data was collected included an eligible performance meter. These meters have a criterion of ± five percent accuracy. They collect cumulative energy production in kWh or Wh, but do not collect data on system performance during specific periods, for example at the time of system peak. Instantaneous system capacity measurements (kW) were also collected along with ambient conditions that affect performance.

Data collection issues can contribute to inaccurate performance calculations. For example, the measurements of instantaneous system output (kW) and solar irradiation were made within a few minutes of one another. During periods of full sun, this time difference will not significantly affect measurement results. However, during periods of intermittent clouds or variable irradiance, the measurement time difference could result in inconsistent output and irradiance measurements. In addition, some measurements of solar irradiance were made from the ground due to roof inaccessibility causing another potential error for measurement of expected instantaneous output (kW).

During the site visit, the verifier read the kWh or Wh measurement required for this analysis from the performance meter when available. The verifier recorded the on-site verification date and asked the customer for information regarding the system installation, operation, and meter start date. The customer survey also collected the date of system installation and operation.

Calculation of actual system energy production (kWh) is dependent on the total time the system has been operating. Thus, if the system operating time is misreported, the expected system production could be over or under-reported. The lack of precision about system operational date declines in impact on the expected capacity factor calculation the longer the system has been operating.

When customers did recall the reported system operational date, they often reported it to be identical to the system or meter installation date, which may not coincide in all cases. Some customers reported both dates in month/year format. Because net-metered PV systems are inspected by the utility for safety between the time of installation and operation, customers may confuse the dates of system installation and operation or they may have been operating their system prior to the utility safety inspection.

System Performance Rating Methods

A PV system typically consists of a PV array, an inverter that converts direct current (dc) power to alternating current (ac) power, and now energy metering equipment. A PV array is made up of multiple PV modules, and the output of each module is rated in Watts (W), based on Standard Test Conditions (STC.) The STC rating refers to the peak dc output, measured in W or kW, produced by the PV modules at laboratory test conditions where the cell operating temperature is 25 degrees Celsius, the air mass is 1.5, and solar intensity is 1000 W/m^2. This level of performance will not be achieved over any sustained period during regular system operations since high irradiance produces high cell temperatures. In order for a PV module to operate continuously at STC, the ambient temperature would have to remain below zero degrees Celsius while the irradiance of 1000 W/m^2 is sustained. These coincidental conditions never happen for residential rooftop systems in California with the exception of the higher elevations in the early spring and late fall. The manufacturers also uses a ± five or ± 10 percent standard in the factory production of modules, such that a 100 W module within 10 percent of the 100-W rating may only produce 91 W during the test and still be rated at 100 W.

The Energy Commission uses the PVUSA Test Conditions (PTC) module rating for rebate purposes[14]. The PTC rating conditions are based on an ambient temperature of 20 degrees Celsius, solar intensity of 1000 W/m^2, and wind speed at one m/s. Like the STC, the Energy Commission's use of the PTC rated output refers to the dc wattage produced by the PV modules and is a better representation of a module's operation in ambient conditions than is the STC rating. This rating does not account for the factory production tolerance and does not include any other system loss.

An inverter is used to convert dc to ac electricity in order for the system to be interconnected with the utility grid. Inverter efficiencies vary across load. The formula used by the Energy Commission only accounts for these two factors to calculate the rebate associated with PV system capacity is as follows:

$$\text{Rated Capacity } (W_{CEC}) = \text{PTC W/module x no. of modules x inverter efficiency}$$[15]

Other losses for a system include many other factors including wire loss, module mismatch, maximum power tracking error, shading, dust, and other factors.

Calculating Expected System Generation

Expected system kWh generation can be calculated using any system rating. Either the array STC method, or the method utilized by the Energy Commission to calculate rebate, may be used in the calculation to reflect actual site-specific conditions, either instantaneously with actual ambient condition measurements or on an expected energy production basis using estimated adjustments for local solar resource, orientation, tilt, shading, and typical ambient conditions.

To calculate the expected annual energy production of a PV system, the 30-year average annual sun hours was obtained from NREL based on the system's geographic location. A combination of derating factors related to the specific PV system siting—system shading and orientation—were multiplied by the average annual sun hours and array size to estimate the site-specific expected annual energy production.[16] Multiplying the yearly sun hours value by the site-specific factors and the rating of the array results in the expected annual kWh output of a system identified in this report.

Derated STC Capacity

A derating value of 70 percent can be applied to the array STC rating to estimate a typical operating peak PV kW_{AC} system output, according to the Energy Commission's publication "A Guide to Photovoltaic (PV) System Design and Installation," June 2001. This rule of thumb has been shown to be a good indicator of typical system performance when measured output is adjusted for actual irradiance at the time of the test. It is used in this report as a benchmark to indicate if a system is performing as expected or not. This method does not specifically adjust for soiling losses that can reduce output as much as 25 percent or more for a very dirty array.

According to this publication, the factors that affect a PV system's operating power output are:

- Actual Conditions v. STC — the output of a module rated under laboratory conditions exceeds actual operating performance. In addition, modules typically have ± five or ± 10 percent production tolerance around the STC rating (five or 10 percent derating).

- Temperature — module output decreases as the module temperature increases. The Nominal Operating Cell Temperature (NOCT) for a typical module is around 45 degrees Celsius. The temperature of modules increase even more above the NOCT value if they are installed on a roof. [17] For crystalline modules, a common reduction factor is 0.89 (11 percent derating).

- Dirt and Dust — dirt and dust can accumulate on the solar module surface, reducing system performance. Rains and cleaning may help reduce dust build-up; however, a typical annual dust reduction factor is 0.93 (seven percent derating).

- Mismatch and Wiring Losses — there are slight inconsistencies in the performance among modules, which account for about two percent in system power loss. System wiring resistance, if kept at a minimum level, contributes to about three percent in system loss (five percent derating combined).

- Dc-to-ac Conversion Losses — as discussed above, inverters also contribute to the loss of system output. This is contributed by the inherent inefficiencies (heat and switching losses) from conversion. An overall conversion efficiency of 0.90 is used to account for these losses (10 percent derating).

Based on the factors described above, overall system losses can total up to 38 percent.

The site-specific instantaneous derated STC capacity can be calculated using this equation:

$$STC_{Derated}\ \text{Capacity} = \frac{70\%\ \text{x STC W/module x no. of modules x measured irradiance}^{18}}{1000\text{W/m}^2}$$

If the measured array output (in kW ac) is less than 90 percent of the derated STC value, then the PV system may be experiencing shading, substantial soiling, wiring, array, inverter, or other problems. This derated STC value provides a good indicator for proper system operation and also acts as a metric for troubleshooting, if needed.

To summarize, **Table 2-5** illustrates the differences in the ratings. The table shows the equivalent rating of a PV system based on a 1.0 kW STC-rated system. To determine typical values, the average percent reduction in rated output from all Energy Commission-listed PV modules was used to calculate an average PTC rating (the PTC to STC rating ratio ranges from 0.85 to 0.96). The inverter efficiency rating was assumed to be 94 percent to convert the PTC rating to the rated output used by the Energy Commission in determining the rebate (system rebate rating) (actual Energy Commission inverter efficiencies ratings range from 87 to 97 percent prior to

April 1, 2005). System ratings can be based on array STC, array PTC or system rebate rating.

Table 2-5
STC, PTCdc, CEC Rated Output, Derated STC PV System Ratings

Rating	kW
Module STC	1.00
Module PTC	0.89
System CEC	0.84
System STC Derated	0.70

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PV System Performance Studies and Metrics

Several California-specific reports review PV system performance metered for research purposes, including two reports prepared for the Energy Commission in 2002 that reviewed systems installed with support from the ERP. More recently, the Impacts Assessment Reports reviewed the performance of systems installed with support from the SGIP.[19] In addition, the IEA PVPS has collected and analyzed PV system performance around the world and across applications since 1999. **Table 2-6** shows the scope of these research reports.

Table 2-6
PV System Performance Report Scope Summary

Parameter	Energy Commission Verification Phase 1 & 2	Energy Commission Performance Monitoring	CPUC SGIP Impact #3	IEA PVPS Task 2
Data Points	132	19	45 (peak hour)	414
Data Dates	5/99-6/02	2/00-12/01	1/03-12/03	1986-2003
Revenue-Quality Meter	NA	No	Partial	NA
Data Collection	On-site Measurement: Instantaneous Generation and Ambient Conditions	On-site data loggers capturing ac and dc kWh, irradiance and module temperature	On-site 15 min interval meters	On-site metering
Instantaneous Capacity Data	Yes (kW_{CEC})	Yes (kW_{CEC}) (kW_{CEC}/STC_{dc})	Yes (peak hr)	No
Capacity Factor	No	Yes	Yes	No
Actual v. Expected Generation	No	No	No	Yes – Annual Performance Ratio
Quantitative Capacity Value Results (kW)	69% of systems performed between 60% and 90% of expectedkWh/ kW_{CEC}	62% = Ave. estimated (kW_{CEC}) v. nameplate (STC_{dc}) system peak capacity *(Range: 53% - 70%)*	59% = Ave. estimated actual capacity v. kW_{CEC}	
Quantitative Energy Production	NA	1151 kWh/kW_{STC}-yr = Average annualized energy *(Range: 622 – 1740 kWh/kW_{STC}-yr)*	17% kWh/kW_{CEC} = Average annual capacity factor	70% =Annual performance ratio of actual generation v. theoretically available generation for on-grid systems[20]

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The conclusions from this research summary are that a common system for key metrics of system performance is still evolving. The questions remaining are: should capacity measurement be adjusted to reflect PTC conditions, peak conditions, or ambient conditions? Should generation measurements be presented on a capacity-factor basis to compare against central station plants, and if so, what rating should be used in the denominator? Alternatively, is PV generation better viewed on a kWh/kW basis, often referred to as system yield, or as a percentage of expected generation compared to optimal PV generation?

Instantaneous PV System Capacity

The goal of this analysis was to assess how instantaneous performance of verified PV systems compares with performance adjusted for solar irradiance. To perform this analysis, measured instantaneous power (kW) was measured and compared against the array power rating (kW_{STC}), adjusted for solar irradiance.

The measurements required to establish instantaneous system performance were solar irradiance in Watts per square meter collected using a pyranometer, and Watts ac (or Volts and Amps ac-this assumes unity power factor and can produce some measurement error that overestimates inverter output by five to 10 percent) collected using a multimeter. The calculations for expected instantaneous power output were:

$$\text{Adjusted Array Power } (kW_{stc}) = \frac{kW_{STC}\text{/module x no. of modules x Measured Irradiance}}{1000W/m^2}$$

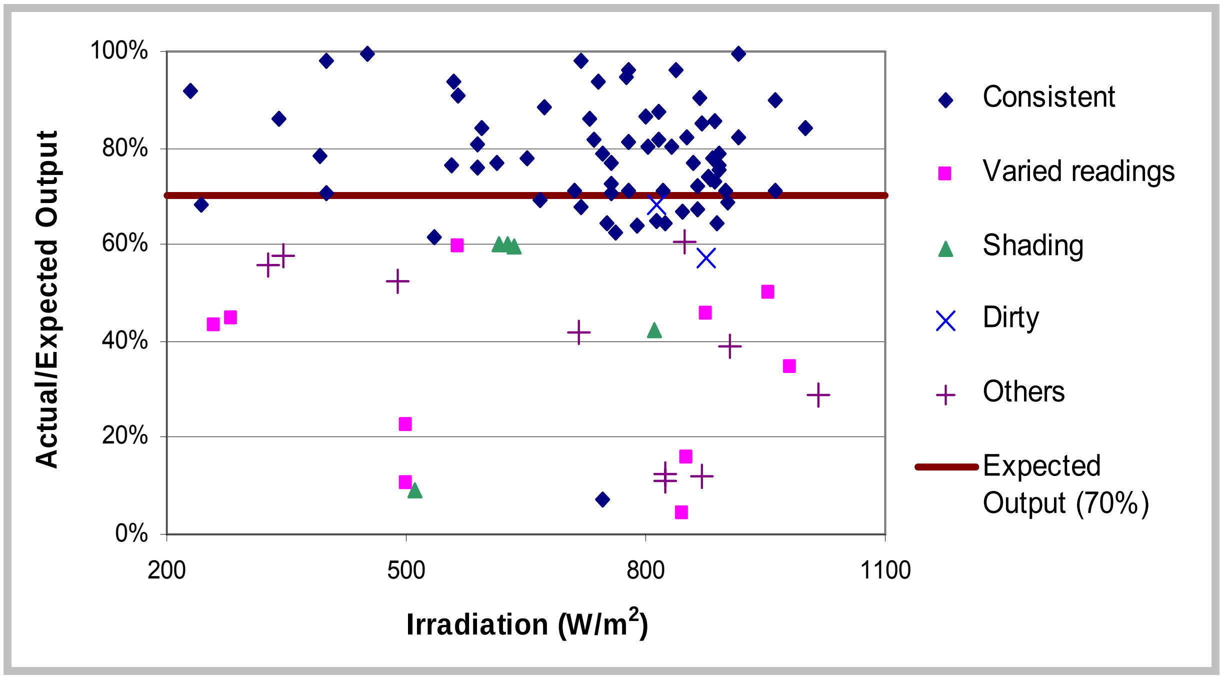
Data from 95 verified sites were used in the results for instantaneous system power (kW). Excluded data are the following:

- Measured values with irradiance measurements < $200W/m^2$ (18). The pyranometer sensitivity used to collect this data is not accurate at these values.

- Measured values with a measurement that exceeded the adjusted array power (7). These data were removed because they suggest data error; a system cannot perform substantially better than the modules alone at the STC rating.

- Data from the retailer with multiple complaints added at end of site verification.

Figure 2-11
Measured Instantaneous PV System Power as a Percentage of Irradiance Adjusted Array Power (N=95)



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The average value of the ratio of measured KW to the adjusted array power is 67 percent, just below the 70 percent benchmark. However, over half of systems included in this data are performing better than the 70 percent benchmark level. About a quarter of the systems are between 50 and 70 percent of the irradiance adjusted array power and the last quarter is dispersed below 50 percent.

Most of the sites are clustered between irradiance values of 500 W/m^2 and the STC rating level of 1,000 W/m^2. This result indicates most site visits included in these results were measured during moderate to good solar irradiation times. Other relationships were explored with the instantaneous data but not found to offer relevant relationships. Specifically, neither installer categories nor date of installation was correlated to instantaneous performance.

High percentage ratios may indicate that 70 percent is a conservative derating factor. The derated array kW_{STC} is based on various factors and may be exaggerated in certain situations. These situations may be cooler than expected module temperatures, minimal wire losses, and effects due to module mismatch. Inverter ac measurement error could be producing inflated output performance in some cases.

Outliers:

- Of the quarter of sites for which results fell below 50 percent of the adjusted array power kW_{STC}, 13 had varied readings while following on-site measurement protocols, six had shading issues, two had dirty systems, and six had other issues.

- Varied readings indicate that at those sites' output varied during the measurement period. While on site, verifiers were instructed to record the irradiance output over a period of five minutes (other data for a period over 30 seconds). If ac wattage or irradiance varied greatly during the measurement period, e.g., due to clouds, this was noted for the sites in the figure.

- Shading is detrimental to instantaneous and long-term output. At six sites shading was significant on the panels at the time of observation and contributed to the low percentage of instantaneous expected output.

- Dirty panels can easily contribute up to seven percent annual reduction in system output. Instantaneous losses due to soiling can be 25 percent or more after a long dry season. Two sites were noted particularly for their unusual build-up of dirt and dust.

- "Others" are sites that have at least one of the following circumstances: output only from one inverter instead of two on site; installation issues related to wiring; low measured irradiance of less than 350 W/m^2; or time between irradiance reading and power measurement may have been too great to get an accurate instantaneous value.

System Capacity Factor

The goal of this analysis was to determine the capacity factor of verified systems and compare it against other studies and standard industry expectations. To perform this analysis, verified systems' capacity factors were calculated using measured data and compared to a range of expected values (15 to 20 percent). Capacity factor results were reviewed for correlation with factors such as number of days of operation and installer category. The data was not adjusted for overweight summer and winter data. The results are not statistically significant, but the average capacity factor was within the expected range.

During the site visit, the verifier read the kWh or Wh measurement required for this analysis from the performance meter when available. The verifier recorded the on-site verification date and asked the customer for information regarding the system installation, operation, and meter start date. The customer survey also collected the date of system installation and operation. The calculations for capacity factor were:

$$\text{Capacity Factor} = \frac{\text{Measured kWh}}{kW_{CEC} \times \text{Metered Hours}}$$

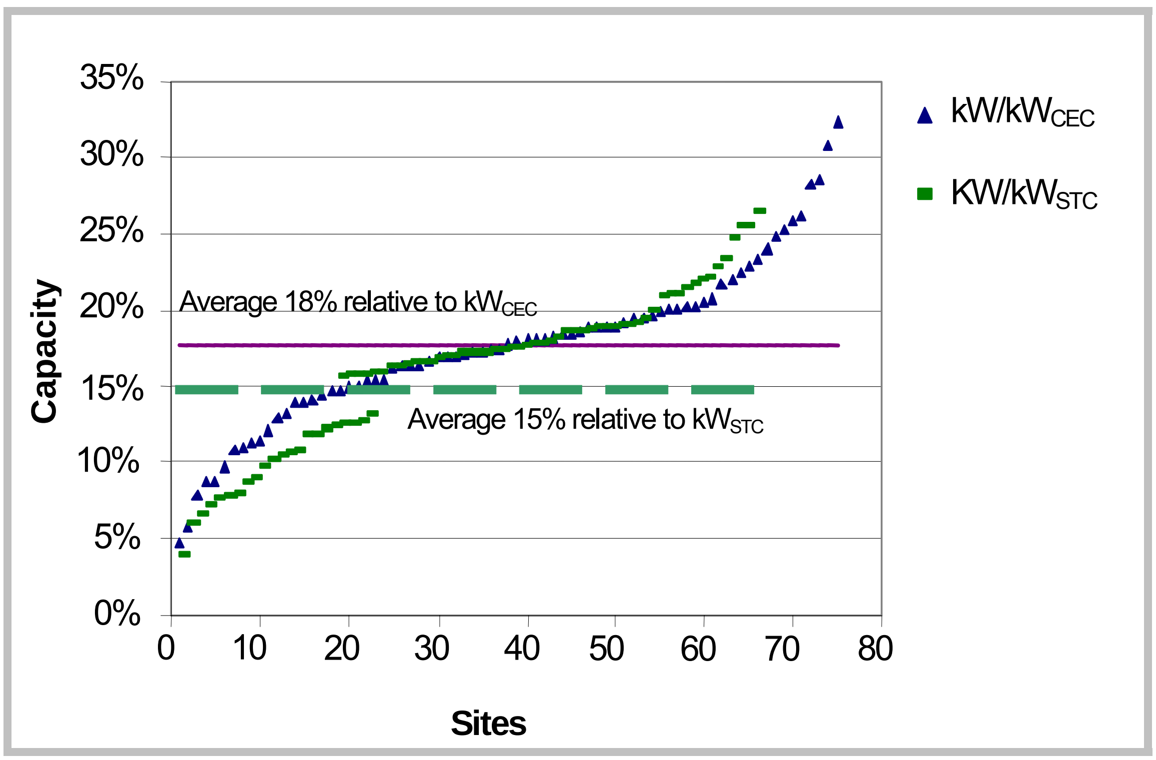
$$\text{Metered Hours} = 24\ \text{hours/day} \times \text{Metered Days}$$

The other factor in this equation is the Energy Commission system rebate rating taken from the ERP database or corrected from the database value to reflect the actual system characteristics observed on site.

Data from 75 verified sites were used in the results for calculated capacity factor. The following data were excluded:

- Data with capacity factor calculations greater than 30 percent (5).
- Data from the retailer with multiple customer complaints.

Figure 2-12
Capacity Factor Calculated from Recorded Performance Meter Data and Reported Operational Date for Verified Sites (75)



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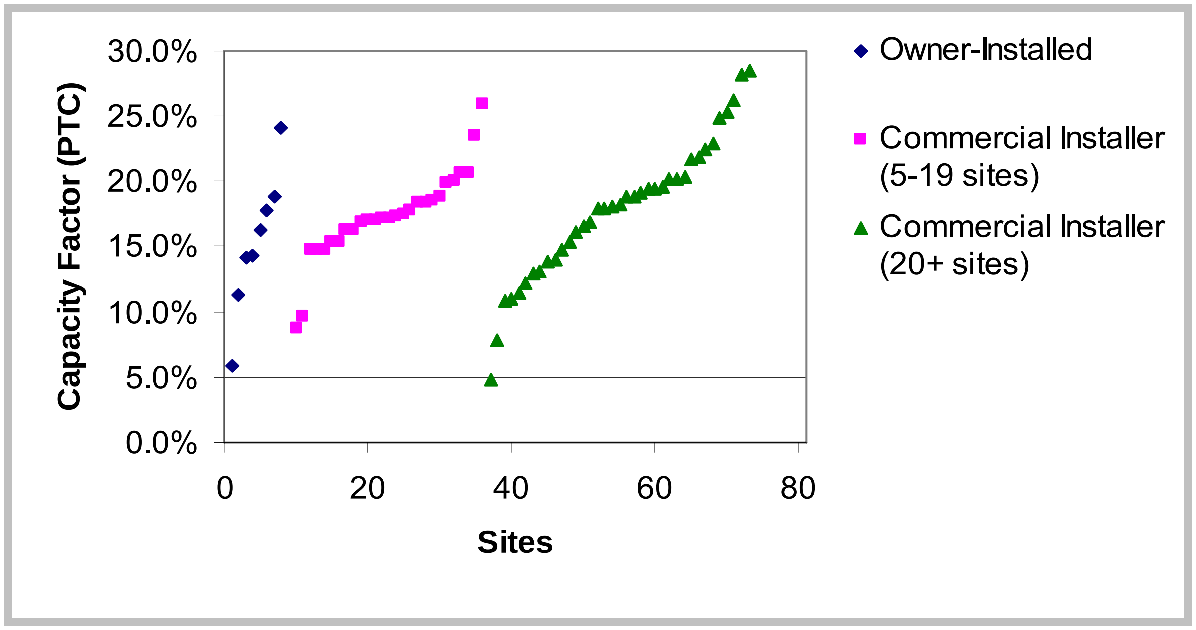
The average capacity factor for the systems included in this calculation is 15 percent compared to the array rating and 18 percent compared to the rating used by the Energy Commission in its rebate program. There is a lot of variation in the way the data was collected but the average is consistent with the band of capacity factors of 15 to 20 percent often used in forecasting PV system performance.

Figure 2-13
System Capacity Factors relative to rebate calculated output as a Function of Installer Category



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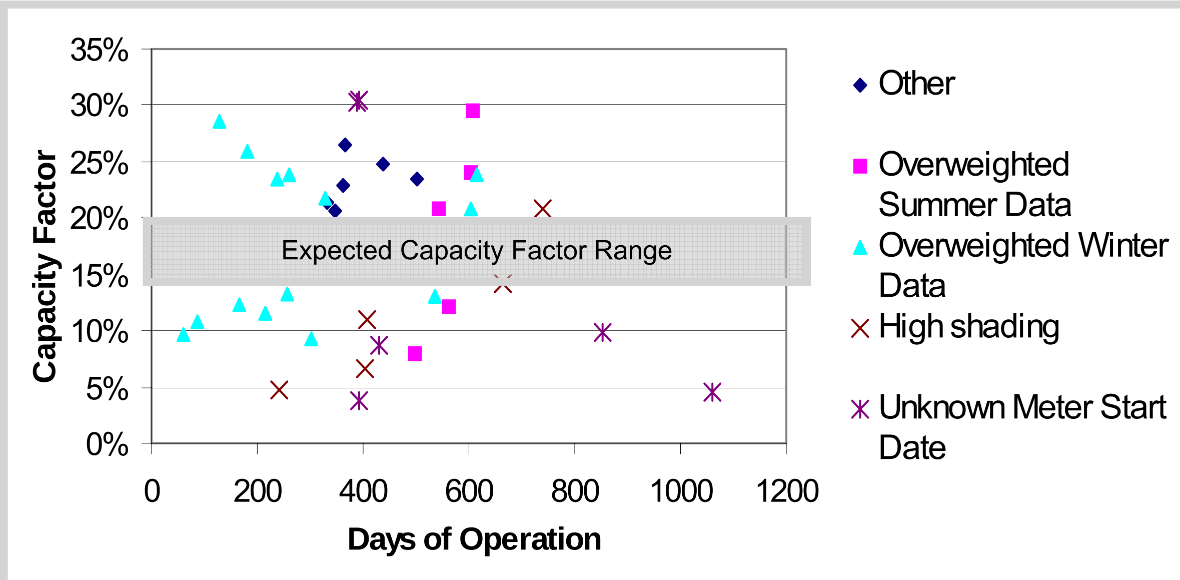
Reviewing capacity factor values by installer category does not shift the average for either commercial installer. The 27 sites served by commercial installers with experience installing between five and 19 systems are more tightly distributed than the 39 sites served by commercial installers with 20 or more system installations. **Figure 2-14** reviews the issues associated with each of the sites with a capacity factor that fell outside of the 15 to 20 percent band. This chart displays the capacity factor versus the number of days of operation, a metric which appears to have no obvious correlation with system performance.

Figure 2-14
System Capacity Factors (kWh/kW$_{CEC}$) Outside Expected Range Segmented by Site Characteristic v. Reported Days of Operation



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Of the total of 75 systems for which capacity factor was calculated, 33 fell outside of the 15 to 20 percent band; 20 of these were calculated to have performed better than a 20 percent capacity factor, while 13 systems were calculated to have performed at lower than a 15 percent capacity factor. Eighty-three percent of the outliers (62) fall within the 10-to 25 percent band.

Table 2-7
Factors Contributing to Capacity Factor Variations
(36 Sites– 50 Identified Factors)

Factors	Quantity
Data from partial year (summer)	5
Data from partial year (winter)	14
High shading	10
Meter start date	9
Orientation of Flat Surface	7
Other	6

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Outliers:

Overweighted summer data sites had operation that had substantially more summer than winter days, while overweighted winter data sites had substantially more winter than summer days.

Overweighted summer data should lead to a higher calculated capacity factor, and for four sites that is the case. However, two overweighted summer data site fall below a 15 percent capacity factor. One of these sites had high shading but the other site is likely a meter start date error. Overweighted winter data sites should lead to a lower calculated capacity factor, which is true for seven sites. However, seven overweighted winter sites have calculated capacity factors above 20 percent. This equal dispersion of overweighted winter sites around the expected band of capacity factors suggests that there are likely other factors affecting the capacity factor calculation, such as the customer reported meter start date.

Four of five highly shaded sites were calculated to have capacity factors lower than 15 percent. The single site with higher capacity factor is a likely candidate for meter start date error.

There are nine sites where the meter start date is clearly an issue in accurately calculating system capacity factor; four of these have a seasonal overweighting. The data is questionable either by the verifier's notes, contradictory information provided (on survey and on-site data collection), or known inverter replacement (display meter on inverter does not show energy since inception).

Six sites have other unknown reasons for having capacity factors outside the 15 to 20 percent range. Sites may have more than one reason for not having an expected capacity factor. Some of the sites that have partial-year data may also experience high shading, unknown meter start date, bad orientation (such as west-facing array), or flat installation.

Seven sites had very low relative energy production—under 40 percent. These results can be accounted for largely due to issues related to meter start date (or inverter replacement, hence the performance meter is replaced as well) or multiple arrays and only one array has tilt, orientation, and shading data attributed to the expected kWh calculation. In particular, one site had an array on another section of the roof that had difficult access. This array had more shading which was not accounted for in the results.

Cumulative Energy Production by Region

The goal of this analysis was to compare actual system energy production by geographic region. To perform this analysis, the actual metered data were collected and normalized to kWh/kW_{STC}. Regional variability in results reflects differences in latitude and irradiation. However, as illustrated in **Table 2-8**, the small number of sites available with actual metered data in some regions means that these results should be viewed as merely indicative.

Table 2-8
Annual Energy Production by City: kWh/kW_{STC} Array Rating[21]
Best Case Versus Recorded Meter Data

City	Best Case Energy Production Range (kWh/kW_{STC})	Average Energy Recorded (kWh/kW_{STC})	Actual Vs. Low End of Best Case	Count of Systems
Fresno	1505-1881	1362	90.5%	10
Sacramento	1455-1819	1368	94%	17
San Diego	1406-1758	1228	87.3%	8
San Francisco	1379-1724	1319	95.6%	17
Santa Maria	1422-1778	1382	97.2%	6

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All but San Diego are within 90 percent of the best case performance. The best case range denotes the performance of a PV system at an ideal tilt angle (30 degree tilt facing true South), no shading, and no soiling of the array. Very few residences have ideal conditions, so it is very common to see values that are 90 percent of ideal. These data should be considered indicative a typical residential PV system performance.

Outliers:

San Diego sites had the lowest energy production compared to the other areas. Of the eight sites with actual meter data, three had significantly lower output expectation. These three sites had unclear meter start dates per the verifier's observation. Two sites had inverters replaced and so the meter data and start date may not coincide. In addition to meter start date issues, San Diego has significant variability in solar resource from the coast to inland sites. Also being north or south of the city can have an impact. The data used to provide the best case performance is based on the airport weather data that is located very close to the city downtown area.

Annualizing the actual meter data will lead to overweighted summer and winter results. On average, for a random sample of systems, these seasonal overweightings will average out. However, the spread of results will reflect the seasonal overweighting.

Best case performance is based on long-term averages during the 1961-1990 time frame to model the monthly and yearly energy productions (NREL 30 year solar radiation data). Weather variations may be as much as 40 percent for individual months and up to 20 percent for individual years. Compared to long-term performance over many years, the values in the table are accurate to within 10 percent to 12 percent.[22]

Non-Operating Systems

Six systems were not operating or partially not operating during the verification visit. Two of these systems were pre-selected sites, and four were from the random sample. **Table 2-9** provides basic information about each of these sites.

Table 2-9
Summary of Non-operating Sites or Partially Non-operating Sites

Res ID	Problem
3650	System was not generating electricity while verifier was on-site. The inverter light was on but no voltage registered. A wiring error is the likely cause of the problem.
4983	Initially 1 of the 2 strings were not working at all because a fuse was blown. After replacement, the string functioned again. Fuse clips were partially deformed as a result of heating that could result in a failure.
6507	Low inverter efficiency, low wire size, redundant fuses, crimp connector losses, water in PV jbox. One module looked "ruined" and the another badly corroded inside its jbox and its wires had corroded completely. The "ruined" module had no output, so the others in the same string were not contributing. After rewiring the less corroded module, the rest of its string came back online.
11660	Only one of the inverters has output. The second Sunnyboy inverter was not performing for duration of visit. Owner said the display meter often shows "check system" status, while inverter's "Error" light comes on.
17243	System was not operating while verifer was on-site. It was waiting for Edison's approval. The verifier contacted the site owner two months later and confirmed that the system was operating.
19819	System was not operating while verifer was on-site. It was waiting for Edison's approval. The verifier contacted the site owner two months later and confirmed that the system was operating.

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Company with Multiple Customer Complaints

The Energy Commission identified one company who was suspected of providing incorrect information to the Energy Commission and inadequate service to its customers. KEMA-XENERGY conducted telephone interviews with 16 of the company's customers and then followed with by selected on-site verifications based on telephone interview results. After six full on-site verifications and five limited-access visits, issues were identified in all but one of the installations. Problems ranged from inconsistencies in the reporting of equipment size to customer-reported unsatisfactory work by the installer. Of the list of 20 customers provided by the ERP Project Manager, four customers could not be reached. During the on-site visits, one customer's address could not be located.

Figure 2-10 summarizes the problems identified by the verifier or the customers.

Table 2-10
Potentially Fraudulent Retailer Verification Results

Res ID	Equipment Size	System Not Operating	Performance Issues	Unsatisfied with Installer	Invalid Contact	Level of Verification
Total	**6**	**2**	**5**	**6**	**4**	
10138	X					Full on-site
10596					X	Cannot contact
10622	X					Phone interview
10623	X					Phone interview
11736					X	Cannot contact
11880						Phone interview
12378			X			Phone interview
13525					X	Cannot contact
14589				X		Full on-site
14590						Limited-access
14871			X	X		Full on-site
15260	X		X	X		Full on-site
16824				X		Limited-access
16381					X	Limited-access
17243	X	X		X		Limited-access
16811						Phone interview
18650	X		X			Full on-site
19030			X	X		Limited-access
19817						Full on-site
19819		X				Limited-access

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The company reported inaccurate technical data to the Energy Commission for some of its customers. Three of the sites visited have a smaller system than reported, either because of a reduction in the number of PV modules, a downgrade of module wattage, and/or a downgrade of the inverter size. One of these sites had all the PV modules on site but not installed.

Two sites visited were not operating at all because the systems were waiting for Edison's approval.[23] Two systems were producing significantly lower output than expected. Several modules at one site were shaded by a palm tree due to limited available space. Another site performed poorly apparently due to significant dirt build-up on the panels.

This particular installer's customer satisfaction was very low. Almost half of the customers contacted reported that they were not satisfied with either the energy output of their PV systems or the services provided by their installer. Five customers were unhappy with the system performance and six customers were unhappy with the installer. Three customers specifically commented that the installer failed to install some PV modules, did not refund the customer for unused panels,[24] or failed to zero their bill as they were led to believe.

Wind Sites Results

Sample requirements for wind sites were met through five verification visits. Three were installed by the same installer/retailer and the other two were owner-installed systems.[25] All installed wind systems were tilt-up towers and pole type: four guyed and one free standing. Two had performance meters and one was a time of use customer. One wind installation had batteries. None reported bird deaths.

Both of the owner-installed systems were PV-wind hybrids with batteries. One of the sites had trees at the same height as the turbine at 37 feet high and about 20 feet away. The other site was in a poor wind area with an estimated turbine height of 18 feet. Both owner-installers of these sites knew that their locations were poor for wind systems; but indicated that they only pursued wind installations because they were “free” with the rebate[26].

All of the installations by the commercial installer had the same 80-foot tower. None of these systems were PV-hybrid systems. Two of the three turbines installed by the installer/dealer had issues.

One owner was falsely led to believe the following:

- They would receive batteries with the installation, but later they were told that battery installations did not qualify for a rebate.

- The system's inverter would self-reset in the event of a fault. At the time of our verification, the inverter required manual reset.

- The system had low noise levels; however, the customer complained of an inappropriate noise.

- The customer would receive product manuals but never did.

- The turbine output would essentially cancel out their power bill. (Medical equipment installed at about the same time more than doubled electricity consumption leaving them high utility bills and a sense of disappointment with the turbine.)

One owner had a bad overall experience with the installer:

- A permit was never obtained. (They got in trouble with the building department about their installation when they later expanded the house.)

- They had intermittent power outages during high-wind periods, allegedly caused by their wind system. (They had more outages than their neighbor who is not a wind system user.)

- Batteries, wires, transformer, and other components were undersized.

- Turbine manufacturer came and did major repairs for free.

The third installation was at a sod production facility. During the site visit, the wind system was producing 150 Wdc at an estimated wind speed of 8.4 mph at hub height, reasonable according to the manufacturer's performance curve. From the annual production curve at a 10 mph average wind, it is expected to have 11,000 kWh/yr. Their meter had a reading of about 2500 kWh for the year (meter started on March 13, 2003). Three possible explanations were the need to reset system several times, the meter operation date was wrong, or the highly uncertain estimation of the site having a wind speed of 10 mph (based on tree flagging).

3: CUSTOMER SURVEY RESULTS

The purpose of the customer survey was to obtain information on program participants' overall satisfaction with the program. The survey aimed to trace their entire participation experience, starting from their motivation for purchasing their renewable energy system, their satisfaction with the equipment itself, their installation experience, any behavioral changes they made, and other post-installation sentiments.

In total, 283 surveys were mailed or handed to photovoltaic (PV) owners along with an introduction letter. [27] Of these, 11 packages could not be delivered and were returned to sender.[28] At the time of the preparation of this report, 170 surveys were completed and returned, representing a 63 percent return rate. At least 106 surveys returned were from sites verified, and at least 54 surveys were from customers who did not receive a site visit but were in the verification sample frame.[29]

Survey Respondents Characteristics

Most of the survey respondents (89 percent) made the purchase decision on the renewable energy systems either themselves or with their spouse or partner. Only 12 respondents (7 percent) reported being the spouse or partner of the decision maker. There were four respondents who did not make the decision to purchase or install their renewable energy system because their system was included in the purchase of their properties. The respondents as a group, were 80 percent male and 78 percent were age 45 or older.

Reflecting the recent, rapid growth of the Emerging Renewables Program (ERP), 80 percent of systems purchased by these customers were installed between 2002 and 2003. Of the 105 respondents whose sites were also verified, 84 percent of the sites are residential, 8 percent are commercial, and the rest are residential/commercial combinations.[30] With regard to occupancy, 43 percent of the properties are usually occupied by two people and 42 percent are usually occupied by three to five people. Over half of the respondents who reported to have occupancy of six or more are commercial sites.

Aside from the fact that only one property was rented and all others were owned, there are no dominant traits related to property size, age or value. **Figure 3-1** shows the broad tendencies for the properties to be valued between $250,000 and $750,000 and sized between 1,000 to 3,000 square feet.

Table 3-1
Number of Occupants Usually on Property (N=166)

Number of Occupants		
0	2	1%
1	9	5%
2	71	43%
3 or 5	69	42%
6 or more	15	9%

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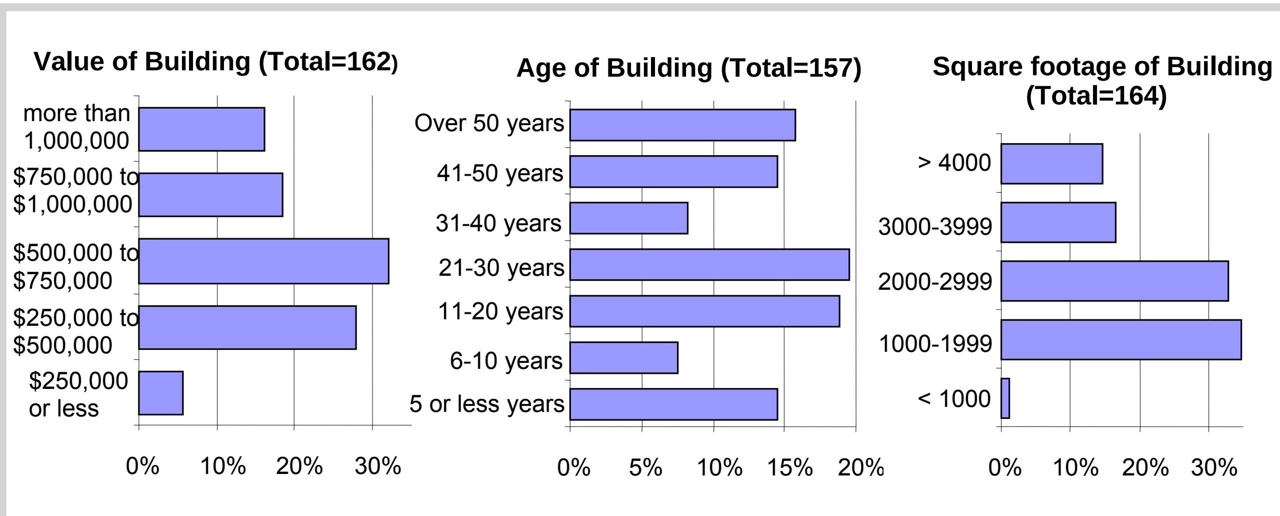
Figure 3-1
Characteristics of Building Types



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Information on Renewable Energy System

Customers were asked where they would send people for information on renewables, and a majority of them suggested the Energy Commission or their contractor (see **Table 3-2**).

Table 3-2
Sources for Information on Renewables
(N=162. Multiple Answers are Accepted)

Where would you send people for information on renewables?		
California Energy Commission	115	71%
Contractor	100	62%
Other Internet Site	42	26%
Magazine or Trade Journal	28	17%
Not Applicable	5	3%

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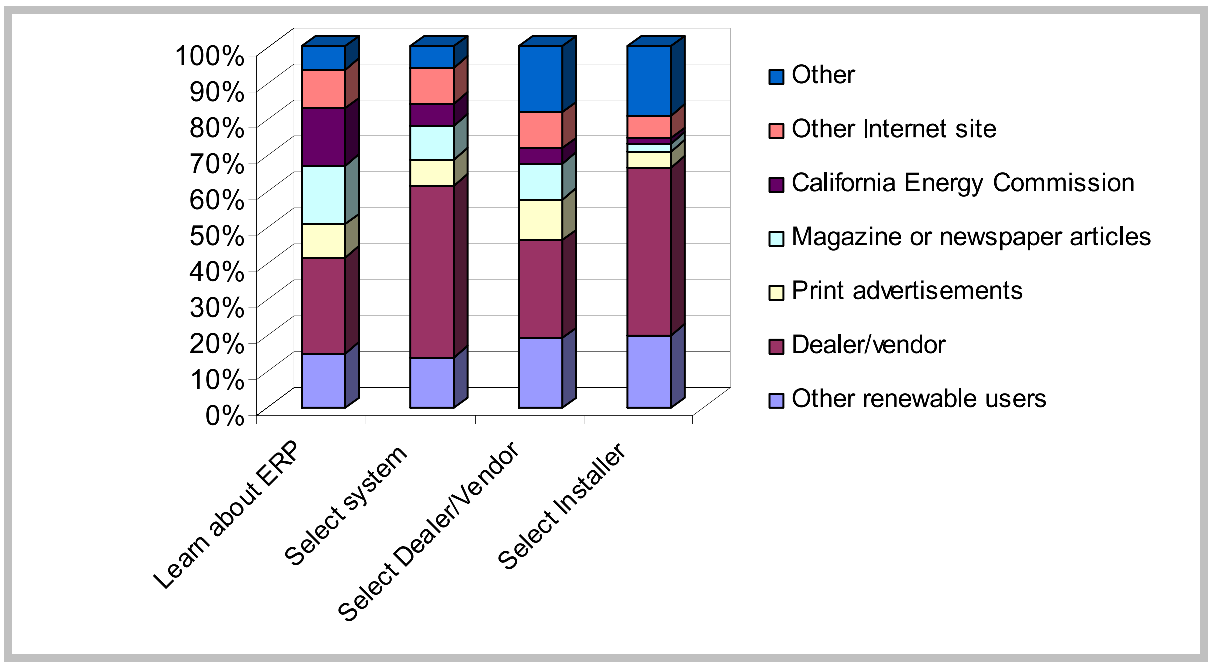
Respondents suggested that their contractors (vendor or installer) were the primary source of information for several aspects of their renewable energy system. Although purchasers consulted a variety of sources during their purchasing process, as shown in **Figure 3-2**, the dealer/vendor was the most frequently reported source for learning about the ERP, selecting system, dealer/vendor and installer.

Figure 3-2
Sources for Purchase Decision (Total Varies)



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Of 163 respondents, 116 (68 percent) obtained an estimate of typical annual energy prior to installation of their renewable energy system, but only 65 of these customers could name it. On February 19, 2003, a revised ERP Guidebook was adopted to require contractors to give an estimate of annual energy production to their customers. This Guidebook became effective on March 3, 2003. Among those who did not know their annual energy estimates, most of them (67 percent) had an application approval date prior to March 3, 2003. The rest who did not have an estimate either had an application approval date after March 3 or the approval date is not available.

Customers who received annual energy production estimates prior to installation were only somewhat more accurate in their monthly savings expectations than those who did not. **Table 3-3** shows these customers are only slightly more accurate in predicting their monthly savings compared to the rest of the population.

Table 3-3
Information on Annual Energy Production vs. Monthly Savings Estimate (N=165)

Monthly Savings Compare to Expectations	*Did you obtain an estimate of typical annual energy production for your system prior to its installation?*						
	Total	Yes		Yes and can name estimates		No	
Same	49%	63	53%	36	55%	18	40%
Lower	26%	33	28%	17	26%	10	22%
Higher	13%	12	10%	5	8%	10	22%
Don't know	12%	12	10%	7	11%	7	16%
Total	165	120		65		45	

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Seventy-seven percent of all customers who reported to have an estimate received the information from their vendor or installer. As shown in **Table 3-4**, purchasers are more likely to obtain an estimate if they worked with a commercial installer for installation.

Table 3-4
Sources for Typical Annual Energy Production (N=116[31])

Where did you obtain the estimate of typical annual energy production for your system?						All respondents Total=170
Sources	#	%	Installer type	#	%	
Vendor/Installer	89	77%	1	6	7%	11%
			2	-	0%	1%
			3	34	38%	35%
			4	46	52%	48%
			unknown	3	3%	6%
CEC website	8	7%				
Other sources	10	9%				
No answer	12	10%				

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Besides critical information about the renewable energy systems, many installers and dealers also offer additional information to system purchasers. Over half of the customers received energy savings or conservation ideas from their contractor, and over one third were urged to include batteries to their system. **Table 3-5** shows that the suggestions of energy savings and conservation ideas are more common among large commercial installers who installed more than 19 sites. The suggestion to include batteries in the system was also popular among medium and large commercial installers.

Table 3-5
Other Suggestions by Dealers or Installers (N=170)

Did the installer/dealer suggest any of the following in your discussions about purchasing your renewable energy system?			Commercial Installers		
			Small	Medium	Large
			4	57	77
Energy Savings/conservation ideas	59	35%	0%	42%	42%
Including batteries in your system	20	12%	0%	21%	4%
Both	42	25%	50%	16%	34%
None	39	23%	50%	21%	21%
No answer	10	6%	0%	0%	0%

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With regard to understanding their net-metering electric utility rate, only 55 percent of all respondents reported that they were aware of the rates and were taking advantage of the benefits. **Table 3-6** shows that 70 percent of all respondents were aware of the net-metering rates, and 79 percent of these customers reported that they were taking advantage of the benefits. Notes on this question suggests that some respondents answered no because they were unfamiliar with the term net metering.

Table 3-6
Awareness of Net Metering Rates (N=167)

Are you aware of "net metering" electricity rates in California?				
Yes			117	70%
	Are you taking advantage of the benefits?			
	Yes	92	79%	
	No	5	4%	
	Don't know	4	3%	
	(blank)	16	14%	
No			31	18%
Don't know			20	12%

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Purchaser Motivations and Complaints

Survey respondents were asked to report all of their motivations for purchasing a renewable energy system. The top reported result was to “reduce their electric bill,” with 89 percent of the survey respondents choosing this answer. In addition, 74 percent of all respondents reported “concern for the environment” as one of the reasons why they purchased the renewable energy system.

Table 3-7 summarizes the primary reasons that participants who responded to the survey purchased renewable energy systems. Promoting or testing new technology received a vote from well over a third of the survey respondents.

Table 3-7
Primary Reasons for People to Purchase Renewable Energy System (N=168)[32]

What were your primary reasons for wanting to purchase and use renewable energy technology? (Multiple answers are allowed)		
Reduce electricity bills	149	89%
Concern for the environment	124	74%
Promote/ Test new technology	61	36%
Become independent of my electric utility	57	34%
Improve the overall reliability of my electricity supply	50	30%
Others	7	4%

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"Become independent of my electric utility" was a factor in 34 percent of customers' decision to purchase renewable energy system. Notably, 50 customers identified "Improve the overall reliability of my electricity supply" as a motivating reason for purchasing their renewable energy system. Of these, at least 26 sites do not have a battery-backed system and 12 sites do. Since this response is more than double the number of battery-backed systems in the sample, it suggests that customers without battery back-up systems may be uninformed that their system will not operate when the utility grid is down.

The survey requested that respondents specify which purchase motivations they deemed most important for their system purchase decision (**Table 3-8**). For the 91 respondents who ranked their motivations by importance, "reducing electricity bill" was the most popular answer, which was followed by concern for the environment.

Customers were also asked about the benefits they receive from participating in the ERP. In **Table 3-9**, the main benefits customers reported receiving were to lower their utility bill (91 percent) and to improve the environment (75 percent). These responses are consistent with the percentage of purchase motivation responses. **Table 3-9** shows the distribution of reported benefits customers have received from the ERP.

Table 3-8
Most Important Motivations for Buying a Renewable Energy System (N=91)

Specify which of your reasons for wanting to puchase and use renewable energy technology is most important.		
Reduce electric bills	45	49%
Concern for the environment	34	37%
Become independent of my electric utility	5	5%
Promote/ test new technology	4	4%
Improve overall reliability of my electricity supply	3	3%

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Table 3-9
Benefits from Participating in the ERP (N=164)

What are the benefits you have received from participating in the Emerging Renewables Program?		
Lower utility bill, saved money	150	91%
Home/ equipment is more energy efficient, uses less energy	70	43%
Improve environment	123	75%
Other	11	7%
Don't know	6	4%

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During the course of on-site verification, phone interviews, and written into the margins of many of the customer survey forms, 31 customers voiced dissatisfaction with their respective utilities. These customers are proportionately distributed across the utilities (**Table 3-10**).

Most of the specific complaints were about the complexity of their monthly electricity statements and the “unfairness” for not being paid for their surplus production. Some customers have more than one specific complaint (**Table 3-11**).

Table 3-10
Customers Dissatisfied with their Utilities (Total Sample=170)

	Dissatisfied Customers		Population
PG&E	22	71%	61%
SCE	5	16%	16%
SDG&E	4	13%	15%
POEU	0	0%	1%
Unknown	0	0%	6%
Total	31	100%	100%

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Table 3-11
Specific Complaints About Utilities (Total Sample=31)

	Total	PG&E	SCE	SDG&E
Billing statements	**12**	10	1	1
Losing energy surplus	**8**	4	3	1
Information or communications	**6**	5	0	1
Monthly transmission fees	**4**	3	1	0
Guideline or paperwork	**5**	2	3	0
Other	**6**	4	1	1

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Over 80 percent of billing statement complaints came from PG&E customers. PV owners from PG&E territory receive monthly statements designed for industrial customers. Copies of the customers' monthly bills show that the multiple pages of numbers, codes, and jargon could indeed intimidate consumers.

SDG&E customers comparatively feel more strongly about losing their surplus energy to their utility. As a customer says," Why don't we get paid for power we generate for the public? Why do we pay all the taxes and levies when we have a credit month?" There is no indication that SDG&E charges higher taxes or minimal fees than the other utilities. This sentiment might be due to a general dislike of the utility, resulting in an exaggerated sense of grievance.

All complaints about insufficient information or communication come from PG&E customers. One complained about the lack of communications between the Energy Commission, the CPUC and PG&E. Two customers complained that PG&E was not informative on its pricing and meter reads upfront; one complained that PG&E was not helpful when called; and one wished that the utility had more communication with the customers.

Both PG&E and SCE customers share the same sentiments about monthly minimal charges regardless of their PV generation. All three PG&E customers were unaware that that there was a monthly minimum charge. A SCE customer simply stated, "Six dollars a month is a lot to pay for giving power away."

The PG&E customer complaints about paperwork were mild. The two dissatisfied customers from PG&E simply wished that the guidelines were "simplified" and that they would "understand [it] better." One SCE customer was unhappy about the "utility bureaucracy" and the time it took SCE to complete the paperwork. **Table 3-19** shows that systems under SCE territories do slack in the lapse-time between installation and operation. The other SCE customer did not specify his complaint about paperwork; he wrote down in his survey that "Edison paperwork/staff [are] a major pain to deal with."

Some notable complaints under "other" include:

"PG&E seems to have more trouble understanding the program than we do."
"PG&E crews don't seem too familiar with this technology and how to shut it down and lock it when working in the neighborhood."

One called PG&E "monopolistic" because it tries to "push through regs that would give them ownership of all PV generated power." One customer complained about how long PG&E took to set up their time of use (TOU) meter. Two customers desire to go off grid without stating specific reasons.

System Economics

The costs of the systems from our respondent population range from under $10,000 to over $100,000. **Table 3-12** shows that over 70 percent of those who reported their system costs own a system that was less than $40,000. The most common price range reported by these customers was between $20,000 and $39,999, accounting for 59 of the 136 respondents or 43 percent.

Table 3-12
Total System Cost (N=170)

What was the total system cost?			
Known total system cost			Total=136
$ 19,999 or less	38	22%	28%
$20,000-$39,999	59	35%	43%
$40,000-$59,999	20	12%	15%
$60,000 or more	19	11%	14%
No answer	15	9%	
Don't know	19	11%	

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Sample frame Category I customers, owner-installed or unknown installer, are more likely to own a system that is $19,999 or less. Thirty-nine percent of Category I customers have a system $19,999 or less, where as the population average is 22 percent (**Table 3-12**). Category III customers, those who contracted installers who have installed between five and 19 sites, own a system that is $20,000 or more. Sixty-eight percent reported that they have a system that costs $20,000 or more. In addition, this group has the best response rate for answering this question. While the average non-response or “don’t know” response rates are nine percent and 11 percent respectively, only three percent and seven percent of Category III customers provided these answers. Category IV customers, those who contracted with large installers who have installed 20 or more sites, are less likely to know their system cost but more likely to purchase systems that cost $60,000 or more.

Of the 126 sites with reported system costs, 47 (37 percent) have at least a 10 percent discrepancy from the ERP database. This discrepancy was investigated for sites with larger reported costs. At least six of these systems were either expanded from or were the expansion of another reservation. For the systems that had lower reported costs in the survey than in the ERP database, at least seven of the sites were suspected to have left out the rebated amount and reported only the net customer cost. Another two sites appear to show only the rebated amount in the ERP database and therefore do not match the reported system cost. Other incongruities might be caused by inclusion of permits fees, state tax breaks, battery costs, or other non-eligible costs.

Customers were asked how they paid for their system, and 75 percent of respondents answered that they paid 100 percent cash.

Table 3-13
Payment Methods (N=166)

How did you pay for your system?		
100% Cash	124	75%
Financed	42	25%

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Four customers did not answer the question, and three of these purchased a house with the system included.

Of the 42 customers who financed their systems, 52 percent used mortgage loans. The loans were reported to have varying interest rates between 3.5 percent to 14 percent and varying payment terms of between half a year (personal loan) and 30 years (**Table 3-14**).

Table 3-14
Finance Methods (N=42)

What type of financing did you use?		
Mortgage loan	22	52%
Home equity loan/Ling of Credit	9	21%
Personal loan	4	10%
Refinanced home loan	2	5%
Equipment loan	1	2%
No answer/ illegible answer	4	10%

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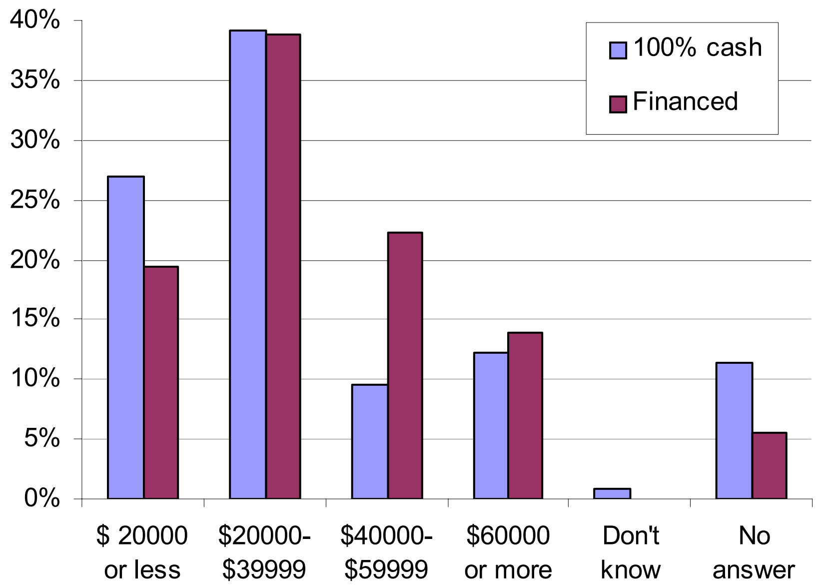
There is a slight correlation between the total system cost and the method of payment. **Figure 3-3** shows that purchasers are a little more likely to pay for their system with 100 percent cash if the system was less than $20,000 and more likely to finance their system if it cost more than $20,000. Moreover, those who do not know their system cost or left the answer blank mostly paid for their system in cash.

Figure 3-3
Payment Methods in Relation to System Cost (N=152)



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Customers were asked what the expected payback would be for their system (see **Table 3-15**). Of 167 respondents 69 (41 percent) reported five to 10 years and 44 respondents (26 percent) reported 15 to 25 years. Over 80 percent of customers who estimated the expectation reported a payback of 15 years or less. Another 24 respondents (14 percent) reported that payback was not a factor in their purchase. Of the customers who answered that payback was not a factor in their purchase, one answered that her payback was 10 to 15 years while the other two did not know their expected payback.

Table 3-15
Expected Payback (N=167)

What did you expect the payback of your renewable energy investment to be?		
2 to 5 years	8	5%
5 to 10 years	69	41%
10 to 15 years	44	26%
15 to 25 years	19	11%
Don't know	5	3%
Payback not a factor	25	15%

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Table 3-16 shows that the rebate level affects the customers' decision to install their renewable energy system. A third of respondents answered that they would have been "not at all likely" to purchase their system if the rebate level had been decreased by half. Seventy-two percent of the current system owners and respondents answered they were "not at all likely" to purchase their system if they received no rebate at all.

Table 3-16
Rebate Level Impact (N=167)

How likely is that you would have installed the renewable system had you…	Not at all likely	Somewhat likely	Very likely	Don't know/ no answer
Received no rebate?	117 (72%)	31 (19%)	12 (7%)	7 (4%)
Received half of your rebate?	54 (33%)	69 (42%)	29 (18%)	15 (9%)

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Of the 25 enthusiasts who answered that payback was not a factor in their purchase decision, over half reported that they would have been "not at all likely" to purchase their system if no rebate had been offered, and about a quarter would have reported that answer if the rebate had been cut in half (**Table 3-17**).

Table 3-17
Rebate Level Impact on Respondents Who Report Payback Was Not a Purchase Factor (N=24)

How likely is that you would have installed the renewable system had you…	Not at all likely	Somewhat likely	Very likely	Don't know/ no answer
Received no rebate?	14 (56%)	6 (24%)	5 (20%)	0 (0%)
Received half of your rebate?	6 (24%)	10 (40%)	6 (24%)	3 (12%)

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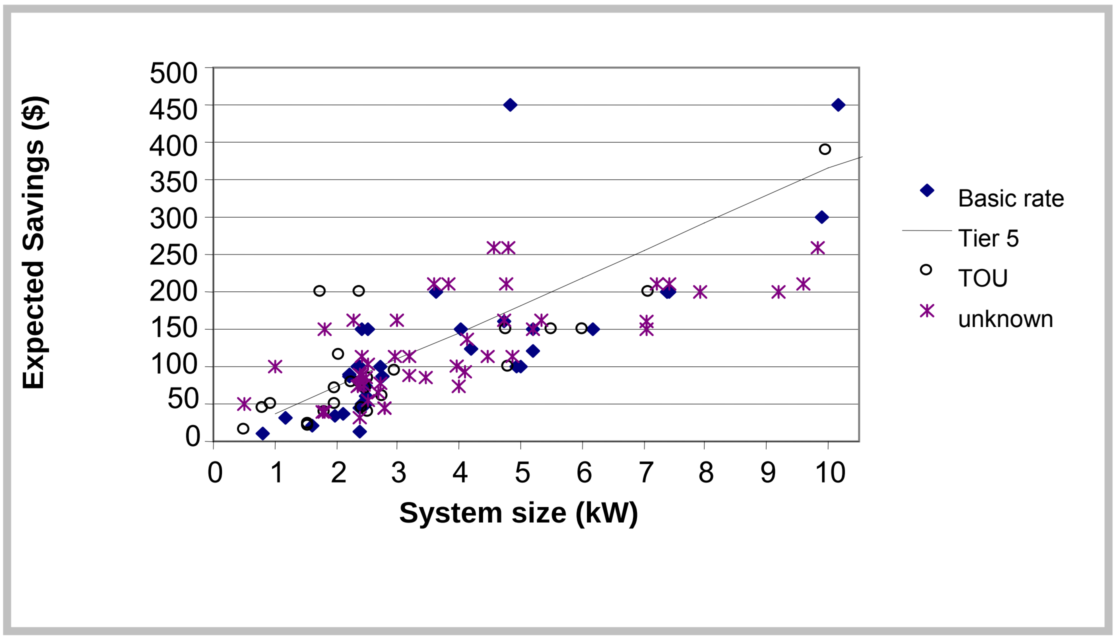
Customers' savings estimates are logically correlated with the rebated system size as illustrated by **Figure 3-4**. The clear variation in savings at a specific system size does not necessarily suggest incorrect analysis of system savings by many of these customers. However, a combination of factors, including residential tiered rates in California's Investor Owned Utility territories, volatility in monthly customer usage, and variations in rate schedule and utility can lead to sizable variations in expected average monthly savings based on marginal avoidable electric rates. The Tier 5 line below approximates the level of savings assuming all avoided generation would have been charged at the highest residential Tier 5 rates in effect in June 2004. It is possible that the Time of Use rate customers who report greater monthly savings than the Tier 5 line are achieving their expected levels of savings but a significant number are not.

Figure 3-4
Estimated Monthly Savings vs. Systems Size
(PTCAC Wattage as Verified) (N=109)



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As illustrated by **Table 3-18**, half of survey respondents report their savings meet their expectations, a quarter report savings lower than expectations, and about 13 percent report savings higher than expectation.

Table 3-18
Savings on Monthly Electricity Compared to Expectations (N=165)

Are your savings on your monthly electricity bill higher, lower or about the same as your expected?		
Same	81	49%
Lower	43	26%
Higher	22	13%
Don't know	19	12%

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Installation Experience

Of 166 respondents, 40 installations (24 percent) were part of other upgrades, remodeling or retrofits to the customers' residence or business. Most respondents, 129 (77 percent) worked with their dealer/vendor to install their renewable energy system. Almost half of this group, 54 respondents (42 percent) also worked with an installer. Twenty-three respondents (14 percent) worked only with an installer to install their system. Another 25 respondents undertook self-installation of which 15 reported that they also worked with their vendor/dealer or installer for installation.

Customers or their dealers/vendors/installers must go through the following steps to successfully operate a net-metered renewable energy system:

1. Select a system and specific equipment
2. Request a rebate from the ERP
3. Receive approval for the rebate from the Energy Commission
4. Get a local building permit
5. Install the system
6. Pass local inspection(s)
7. Receive utility interconnection approval
8. Request rebate payment
9. Receive payment from the Energy Commission.

Customers were asked to give an approximate date of system installation and date when the system began to operate. Due to safety concerns with having net-metered renewable energy systems operating that have not received utility approval, regular system operation is not permitted until after utility approval. It would be very unusual for a customer to pass their building inspection and receive utility interconnection approval in the same week. However, one customer had an operating system the day after it was installed, four customers claimed to have only taken them two days and three customers took four days.

Table 3-19 shows that 99 percent of the 144 respondents reported having an operating system within 6 months of installation and 83 percent of them have an operating system within 30 days of installation. However, less than 20 percent of customers reported having an operating system within 2 weeks of installation. Over 90 percent of the 92 PG&E customers who answered the question have their systems under operation within 2 months of installation, whereas only 79 and 86 percent of SCE and SDG&E customers claimed the same expediency.

Table 3-19
Time-Lapse between Systems Installation and Operation (N=170)

Lapse time	Total number of sites		PG&E	SCE	SDG&E	POEU	Unknown
Within 2 weeks	23	16%	18%	17%	10%	0%	0%
Within 30 days	120	83%	85%	75%	76%	100%	100%
Within 2 months	128	89%	91%	79%	86%	100%	100%
Within 4 months	136	94%	93%	96%	95%	100%	100%
Within 6 months	142	99%	98%	100%	100%	100%	100%
over 6 months	144	100%	100%	100%	100%	100%	100%
don't know (160)	16	9%	9	4	2	0	1
no answer (170)	10	6%	5	1	2	0	2

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Most respondents (62 percent) found getting a system up and running was not at all difficult, whereas seven percent of the respondents found the process very difficult.

Figure 3-5
Level of Difficulty in Getting a System Up and Running (N=168)

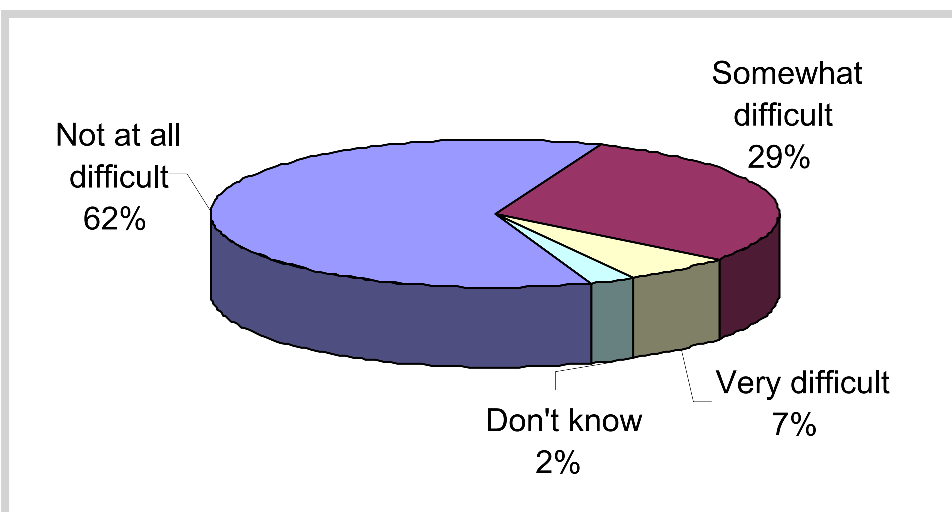

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Table 3-20 shows that sites installed by large commercial installers tend to pose the fewest difficulties to customers.

Table 3-20
Level of Difficulty in Getting a System Up and Running by Installer Types (N=168)

Level of Difficulty to get the system up and running	Total	Self-installed	Commercial Installers <5 sites	Commercial Installers 5-19 sites	Commercial Installers 20+ sites
Not at all difficult	62%	50%	75%	49%	74%
Somewhat difficult	29%	50%	0%	36%	21%
Very difficult	7%	0%	25%	14%	3%
Don't know	2%	0%	0%	2%	3%
Total	168	16	4	59	80

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Although the majority of respondents reported that their overall experience in getting their system up and running was not at all difficult, over a third of them did experience difficulties. **Table 3-21** lists some of the specific challenges reported for renewable energy system purchasers.

Table 3-21
Common Challenges Related to Renewable Energy Systems (Number of respondents varies)

Regarding the selection, design, installation, and operation of your system, have you experienced challenges finding or dealing with any of the following:		
Building Permits (165)	36	22%
The appropriate sizing, performance or cost of the system (164)	31	19%
Installation (165)	29	18%
Information about economic and financial benefits (160)	25	16%
Operation (energy production or power output) (164)	22	13%
A suitable vendor (166)	21	13%
Information about renewable energy incentives (161)	20	12%
Maintenance (162)	18	11%
Financing for installation (157)	4	3%

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Obtaining building permits was one of the main obstacles reported by respondents. Over a fifth of the respondents (36) experienced challenges dealing with building permits. **Table 3-22** shows that SDG&E customers proportionately experienced more challenges in obtaining building permits than customers from other utility areas. However, margin notes from respondents indicate that PG&E and SCE customers feel as equally strong about difficulties in obtaining permits. One SCE customer put four exclamation marks next to his answer and a PG&E customer put two stars next to his. One PG&E customer thinks that, "[the] permit people did not know squat." Another PG&E customer thinks that his county is not open to solar because the permit fees were "ten times more expensive than other cities in the area."

Table 3-22
Distribution of Customers who Experienced Difficulty in Obtaining Building Permits by Utility Territory (N=36)

Experienced challenge in obtaining building permits			Population
PG&E	21	58%	62%
SCE	6	17%	17%
SDG&E	7	19%	14%
POEU	0	0%	1%
Unknown	2	6%	6%
Total	36		170

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Energy-Efficiency Measures

Most of the 168 respondents (79 percent) also considered implementing other electricity bill-reduction strategies.[33] This result is in line with purchasers' motivation for installing renewable energy systems. Of those who deemed bill reduction as one of their motivations for purchasing their renewable energy system, 78 percent also considered other bill-reduction strategies.

Table 3-23 shows that energy efficiency was the most common (92 percent) bill-reduction strategy considered. In addition, 68 percent considered conservation and 62 percent considered both strategies. The write-in elaboration for "other" includes TOU rates and installation of thermal generator. However, the popularity for "other" strategies listed below is slightly exaggerated because write-in elaboration suggests that some respondents consider energy efficiency and conservation measures, such as changing light bulbs and eliminating phantom load, as "other" strategies.

Table 3-23
Bill Reduction Strategies (N=132)

What were the bill-reduction strategies [you considered implementing when installing the renewable energy system]?		
Energy Efficiency	123	93%
Conservation	91	69%
Both	82	62%
Other	18	14%

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Table 3-24 shows that a lighting upgrade was the most commonly reported energy efficiency investment: 84 percent of those who reported investing energy-efficiency measures invested in lighting. In contrast, 44 percent and 42 percent invested in window upgrades and insulation respectively. Other investments reported included energy-efficient dishwashers, clothes washers and dryers, refrigerators and pool pumps. Again, the extent of other efficiency investments might be overstated because the write-in details from respondents suggest that some customers consider Compact Fluorescent Lights and hybrid cars as “other” energy-efficiency investments.

Table 3-24
Energy-Efficiency Investments (N=123)

If you did invest in energy efficiency, what did you do?		
Lighting upgrade	103	84%
Window upgrade	54	44%
Insulation	52	42%
Efficient air conditioner	35	28%
Efficient electric water heater	23	19%
Other efficient appliances	70	57%
Other efficiency investments	23	19%
Don't know	4	3%

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Overall, 31 percent of all 161 respondents participated in utility/state programs that provided incentives for energy-efficiency measures. For those who considered energy efficiency measures when installing their renewable energy systems, 40 of the 117 respondents (34 percent) participated in such programs. These programs included removal or upgrade of old appliances and appliance rebates. Some write-in answers suggest some misinterpretation of energy-efficiency investments including TOU rates, state tax breaks, and the ERP.

In general, most respondents (92 percent) are very satisfied or somewhat satisfied with their energy efficiency investments or programs (**Table 3-25**).

Table 3-25
Satisfaction of Energy-Efficiency Investments or Programs
(N=154)

How satisfied are you with your energy efficiency investments or programs?		
Not at all satisfied	4	3%
Somewhat satisfied	43	28%
Very satisfied	98	64%
Don't know	9	6%

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The results of this section imply that energy efficiency and conservation measures, in general, are complementary to purchasing renewable energy systems. Many purchasers of renewable energy systems reported adopting energy-efficiency or conservation measures since the installation of their system. Of the 101 respondents who changed their energy usage since the installation of energy efficiency equipment, 42 percent adopted conservation strategies, 28 percent replaced existing equipment with a more efficient model, and 14 percent removed equipment. Adopting TOU strategies (switching usage to off-peak hours) accounted for 10 out of the 31 responses for “other” changes.

Some purchasers increased their usage since the installation of their renewable energy system (**Table 3-26**). Of 101 respondents, 24 percent reported to have installed new equipment. Of the 31 respondents who answered “other,” six reported an increase in usage due to addition of new building space or being “not so apprehensive about turning on the AC.” Other write-in responses indicated non-intentional behavioral change or energy-efficiency measures that were already captured in the results above.

Table 3-26
Change in Electricity Usage Since Renewable Energy System Installation (N=101)

Did you change yoru electricity usage since the installaton of the renewable energy system?		
Those who answered yes . . .	101	
Installed new equipment	24	24%
Replaced existing equipment with a new efficient model	28	28%
Removed equipment	14	14%
Conservation	42	42%
Other	31	31%

KEMA-XENERGY, Inc.

Equipment Satisfaction

Most people are satisfied with their systems. If given the opportunity, 95 percent of respondents say that they would purchase their system again and 92 percent would recommend their current system to others. Most respondents reiterated their reasons to buy the system in the first place as the reason why they would purchase the system again.

Customers were given the opportunity to write in answers about how they would like to have changed their purchase process. Two thirds of all respondents gave an answer. Among these respondents, 26 percent answered that they would not change anything. The most common change reported would be their choice of vendor/installer. Eighteen respondents (11 percent) indicated that they would change their vendor, installer or dealer. Their sentiments toward this group ranged from indignation, calling them "absolutely dishonest and incompetent" to mildly dissatisfied, wishing they had "[shopped] around for vendors more thoroughly." Another 11 respondents (10 percent) wished that the systems were cheaper.

Four respondents indicated that they would purchase the equipment again, but a different model. Five respondents would consider buying a larger system if they had an opportunity to purchase the system over again or are thinking of expanding their current system.

Table 3-27 addresses the comments above by asking system owners under what circumstances they would consider purchasing or leasing additional renewables energy generation equipment. More than half of the respondents are very likely to consider purchasing additional equipment if the systems were less expensive. Customers were asked to rank “not at all likely” as 1 and “Extremely likely” as 5.

Table 3-27
Purchasing Additional Equipment (Number of Respondents Vary)

Under the following circumstances, how likely would you be to consider purchasing or leasing additional renewable generating equipment?	
	Likelihood
It was (or equipment was) more widely available (112)	3.4
More widely available, but less expensive (123)	4.2
The equipment were more reliable (107)	3.0
If the energy resource were more reliable (107)	3.0
They (equipment) were more commonly used by others (105)	2.7
It was easier to find out about them (106)	3.0
If a supplier would take all responsibility for operation and maintenance of the unit (109)	3.2
It was easier to obtain long-term financing for the investment at reasonable rates (107)	2.9
Regulatory permitting process were simpler (109)	3.3
If the energy system were less costly to operate and maintain (105)	3.1
If the renewable energy system did not require as much space within my home (or on my property) (110)	3.4
Reduce rebate application processing time (110)	3.2

KEMA-XENERGY, Inc.

Program Satisfaction

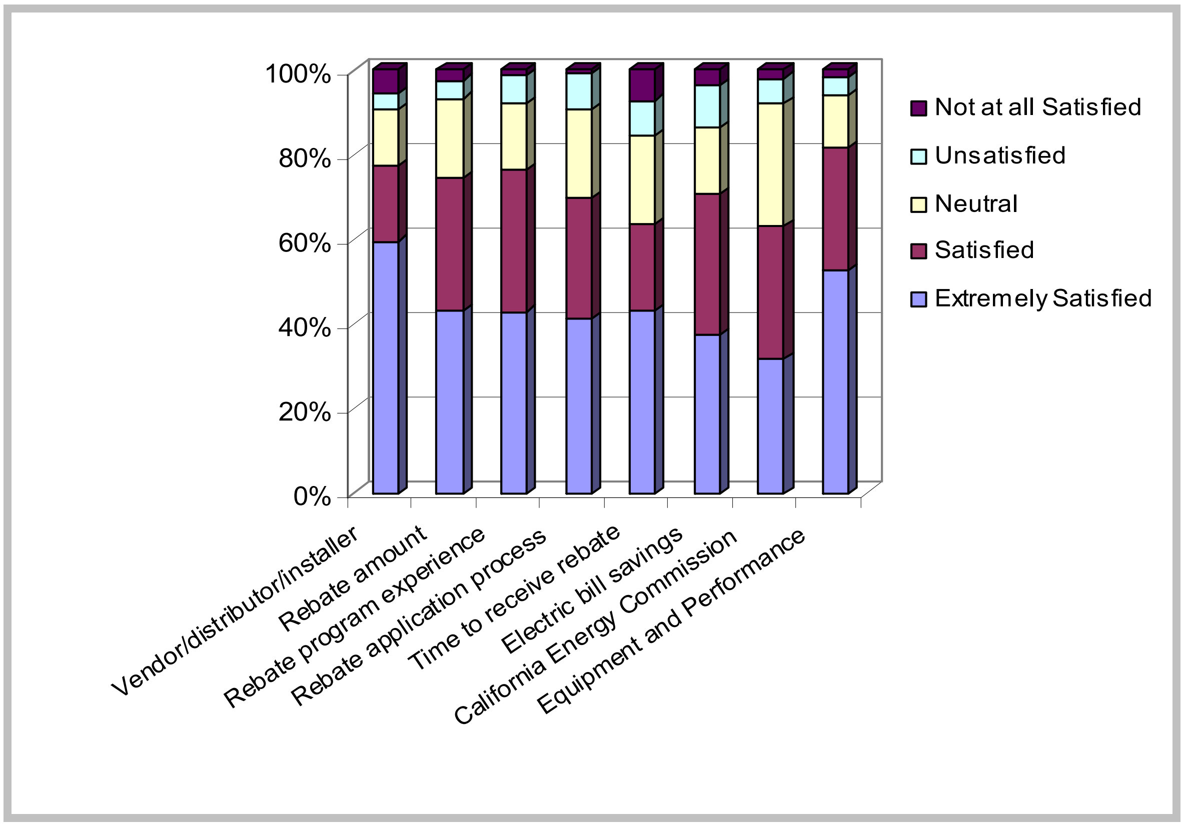
Most customers reported being satisfied with the ERP. Of the 152 respondents who answered the question on whether the ERP was easy to understand and participate in 116 (76 percent) answered yes. As mentioned in Section 4.2, over 70 percent of respondents would send people to the Energy Commission for information on renewables.

However, according to the comments section of the question, many people answered no because they do not recognize the name of the program. Eight respondents commented that they were not aware of such a program or do not know about it. The seven respondents who answered no but did not leave any comments might fall under this category as well. Another four respondents did not distinguish the program from their utilities and answered that ERP was hard to understand because they could not comprehend their utility bills. Two people answered no because their contractor either handled all of the Energy Commission paperwork for them or because the contractor was not helpful with the Energy Commission paperwork. Other relevant comments on not being satisfied with the Energy Commission are as follows:

- Complication on procedures or paperwork (3)
- Not enough information on the rebate or the program (3)[34]
- Frequent changes in rebate amount (3)
- Calculation for rebate amount for additional panels (2).

As shown in **Figure 3-6**, in assessing overall satisfaction, customers were extremely satisfied or satisfied in all categories in the range of 60 to 80 percent. They were least satisfied and most unsatisfied regarding the time to receive their rebate (63 percent) and system savings (71 percent). They were most satisfied by their equipment. The proportionally large number of respondents who answered "neutral" for their satisfaction with the Energy Commission might be attributed to their inability to associate the Energy Commission with the ERP or their association of the Energy Commission with their local governments or utilities.

Figure 3-6
Overall Program Satisfaction



KEMA-XENERGY, Inc.

4: CONCLUSION

ERP Program Compliance

Verification has been successfully concluded for over 150 ERP rebated sites. Among the randomly selected sites some fraud was detected. There were also signs of suboptimal installations due to poor installer practices or carelessness.

In addition, 47 sites were detected with discrepancies between the database and the verified equipment on site. Of those, 31 sites were either system upgrades or change of equipment without a change in expected system performance. Sixteen were detected with system downgrades, where customers might have received a rebate for a system delivered below specifications. Of the downgraded sites one was an owner-installed site, seven were from Category III medium commercial installers and the rest (seven sites) were from pre-selected large commercial installers. One site was flagged as a potential rebate fraud -albeit no performance issue- because a location discrepancy was observed. The falsified system location could be used to dodge restrictions on program system size and decreasing rebate amount.
Aside from the pre-selected sites, two of the 108 randomly selected sites that received full verifications were found to have serious operational defects. Category III commercial installers installed these two sites. Four of the 48 pre-selected sites were found to have operational issues. Two were not operating due to pending utility inspections, one had a burnt fuse, and the last had panels that were nonfunctional.

System Performance

Most of the systems with sufficient data for analysis were operating within their expected range of performance. Instantaneous measurements can demonstrate whether a system is performing consistent with weather conditions. About 70 percent of the sites verified with data sufficient for calculating expected instantaneous performance were operating at or above their expected benchmark output, given the specific weather conditions.

The average capacity factor based on observed output (kWh/kW$_{CEC}$) was calculated at 18 percent based on Energy Commission rated output (kWh/kW$_{CEC}$) and 15 percent compared to array STC rating across 75 sites. Over half of these sites had a capacity factor of over 15 percent compared to 13 percent on STC.

Customer Experience

Customer survey results suggested that most customers were satisfied with their program participation experience. Over 75 percent of the survey respondents found that the ERP was easy to participate in and over half of the respondents would send people to the Energy Commission for information on renewable energy systems.

Cash was used, as opposed to financing, for the system purchase of 74 percent of survey respondents. In addition, 72 percent of survey respondents indicated they would have been “not at all likely” to purchase the system if no rebate had been available. More than half of the respondents reported that they would be likely to purchase additional equipment if the system costs decline.

Customers reported that their decision to purchase a renewable energy system is strongly tied to the perceived economic value of the investment. Reducing electric bills was reported to be the main purchase motivation by 89 percent of survey respondents and was closely followed by their concern for the environment (74 percent). A majority of customers (62 percent) have bill savings the same or better than expected.

As for challenges with installation, 62 percent of the customers did not think it was difficult at all. However, some customers complained about the process in obtaining building permits. Over 10 percent of all participants voiced complaints about their respective utilities in either the customer survey or to our verifiers.

Recommendations

This project has provided insights regarding field operations of retailers; for example, upgrade of systems after a reservation has been submitted, or system removal upon a home sale. Although these activities are not overtly fraudulent, and do not necessarily adversely affect the program or system performance, they do suggest that Program Guidebook compliance discrepancies exist. We recommend that the Energy Commission consider new guidebook language to accommodate post-reservation needs to modify system components providing that those new components offer equal or better performance from a customers’ system.

Phone interviews or direct survey mailings have proven to be an effective way to communicate with the customers and obtain information. The survey instrument used in this round of verification could be simplified and could be tested as a web-based survey to lower administrative costs. One option would be to approach a larger number of customers for performance data and survey responses, but focus on-site visits around sites with suspected performance or fraud issues.

Cumulative system performance is now accessible to homeowners by simply reading their performance meter. The issue of determining an accurate meter start date could be addressed by requiring installers to note the meter start date in a permanent fashion on the meter after utility safety approval is received. Accessing cumulative performance data may be possible by asking for voluntary customer reporting on a one-time or regular basis.

One approach to implement a voluntary customer-reported performance program would be for the Energy Commission to offer all customers an opportunity to register their system's start date and annual energy production in a Energy Commission sponsored database. By participating, the customer could compare their system performance to other systems with similar characteristics and geographic location, offering a new level of consumer education and protection. Such a request will need to be accompanied by a reminder for customers to account for any time the system was not operating. The Energy Commission could prompt customers entering their data in this database to also participate in a customer experience survey and identify links to energy efficiency investment opportunities in their region.

We recommend that the Energy Commission consider methods to achieve greater performance data from ERP systems, including voluntary reporting directly by customers.

Since 30 percent of the sites verified were found to have over five percent reduction in performance due to shading, we recommend the Energy Commission consider a disclosure on the ERP reservation application form regarding system shading. For example, the disclosure might ask whether any system shading is predicted, and if so an estimate of the performance reduction anticipated due to shading.

We recommend that the industry consider voluntarily providing customers with a method of easily verifying their system start date, such as applying a permanent label on the system's inverter identifying this date.

ENDNOTES

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[1] Standard test conditions: The STC rating refers to the dc wattage, measured in W or kW, produced by the PV modules and is based on laboratory conditions where the cell operating temperature is 25° C, an air mass of 1.5, and solar intensity of 1000 W/m^2.

[2] PVUSA test conditions: The PTC_{dc} conditions include an ambient temperature of 20° C, solar intensity of 1000 W/m^2, and wind speed at 1m/s.

[3] California Energy Commission. 2004. *Emerging Renewables Program Guidebook.* Third Edition. http://www.energy.ca.gov/renewables/guidebooks/500-03-001F2.PDF , see p.7

[4] For the rest of the sites (16), data collected indicates that a different installer was involved, but it is not clear whether the ERP database or the purchaser was misinformed. In cases where sellers subcontract out installation to regional installers, this information might be unknown to the customers.

[5] One of the 49 visits was a limited access visit.

[6] Seven of the 53 visits were limited access visits.

[7] AB 29x allocated limited funding for customers of POEU to be administered by the Energy Commission.

[8] The 21 limited access visits are not included in Figure 3-5. Twenty of these were PV installations and 1 was a wind installation.

[9] The other module types include 2 tefzel covered amorphous, 2 glass amorphous, 1 unframed thin film and 1 with both mono and polycrystalline modules.

[10] Five wind sites were excluded. Location of 3 systems in the same housing complex cannot be determined; verifier saw evidence of solar interties but the systems themselves could not be seen from a public area. .

[11] The 140 racks represented 135 sites; 5 sites have two different sets of racks. Another 11 mounting types were unknown due to limited access visits.

[12] 119 arrays and 118 sites were represented.

[13] Full verification of equipment used at 18 sites was not possible because there were limitations in either accessing the site or the roof.

[14] The Commission calculates the PTC rating based on the following:

$$PTCW = STCW \times \left[1 + \beta/_{100} \times \left(20 + 1.389(NOCT - 20) \times (0.9 - \eta) - 25\right)\right]$$

where β = power temperature coefficient

NOCT = nominal operating cell temperature

and η is the efficiency = STC/1000/area of module

[15] Because inverters do not necessarily operate at rated capacity or at peak efficiency, the CEC began using 75 percent load efficiency for its rating method, as of March 31, 2003. Prior to this date, the Commission used peak efficiency. Both values are self-reported by the manufacturer.

[16] Data sources for this calculation include: http://rredc.nrel.gov/solar/old_data/nsrdb/redbook/sum2/state.html and “A Guide to Photovoltaic (PV) System Design and Installation,” CEC, June 2001.

[17] Typically, modules have a 30^{o} C increase above outdoor temperature. From the Draft "Inspector Guidelines for PV Systems" prepared for Renewable Energy Technology Analysis Project of the Pace University Law School Energy Project, August 2004.

[18] Irradiance is abbreviated as IR and is a measure of sunlight in units of W/m^2

[19] Itron. 2004. CPUC Self-Generation Incentive Program Third-Year Impacts Assessment Report.

[20] Jahn, Ulrike, and Wolfgang Nasse. 2003. Performance Analysis and Reliability of Grid-Connected PV Systems in IEA Countries. p. 2. http://www.task2.org/public/download/OSAKA7OC803.PDF

[21] "A Guide to Photovoltaic (PV) System Design and Installation," CEC, June 2001, page 9, Table 2

[22] http://rredc.nrel.gov/solar/calculators/PVWATTS/interp.html

[23] Later contact with both customers confirmed that both systems were approved by the utility and have started operation.

[24] This site might be an upgrade from the original reservation. However, the system that was originally installed was smaller than what was claimed. The customer later requested an upgrade of 40 extra panels. However, only 24 were installed and the customer never received a refund for the panels that were not installed. Data were not available to determine if the installer requested for a rebate for the full set of panels.

[25] Two others were also verified installation. One was a drive by to assure no fraud at a site that resisted setting up an appointment and the other was a self-installed system at a PV site, but the wind installation was not part of the sample.

[26] This occurred when the wind rebates were as high as the solar rebate and a 50% rebate cap was imposed. The cost of wind system is as much as the rebate paid; however, due to the high solar cost, the aggregate system rebate can still stay below 50%. Therefore, the addition of wind will essentially be "free".

[27] Surveys were mailed to all of the 237 sampled customers and the 20 customers pre-selected for the second sample 1-2 weeks prior to our scheduling for a site visit. In addition, 21 surveys from our new sampled sites and 5 training sites were directly handed to the customers. These customers were provided with a return envelope if the verifier could not collect the survey during their visit.

[28] Six were returned due to insufficient or nonexistent addresses; two were not deliverable because recipients were not known at the address; one recipient moved and postal forward time has expired; and two were returned because no mail receptacles were available at address.

[29] Ten anonymous surveys were received after our first round of mailing in March. These may or may not be for sites that were verified. At this time, a process change was implemented based on evidence that customers were comfortable being identified. Thereafter, all surveys mailed out were labeled with the recipients' reservation ID number.

[30] The site left out from this percentage was a limited access site where the type of building was not obvious from afar.

[31] Three respondents obtained the information from both the California Energy Commission website and their contractor.

[32] Respondents who wrote in other answers include: Eliminate dependency on foreign oil (3), good investment (2), help California out of its energy dependency (1), and take advantage of state incentives (1).

[33] Six respondents did not answer yes or no on whether they considered implementing any other electricity bill-reduction strategies. For the four who elaborated on the specific strategies adopted,

their answers were interpreted as yeses. For the two who wrote in “only as need arises” and “already do some of these,” their answers were interpreted as no.

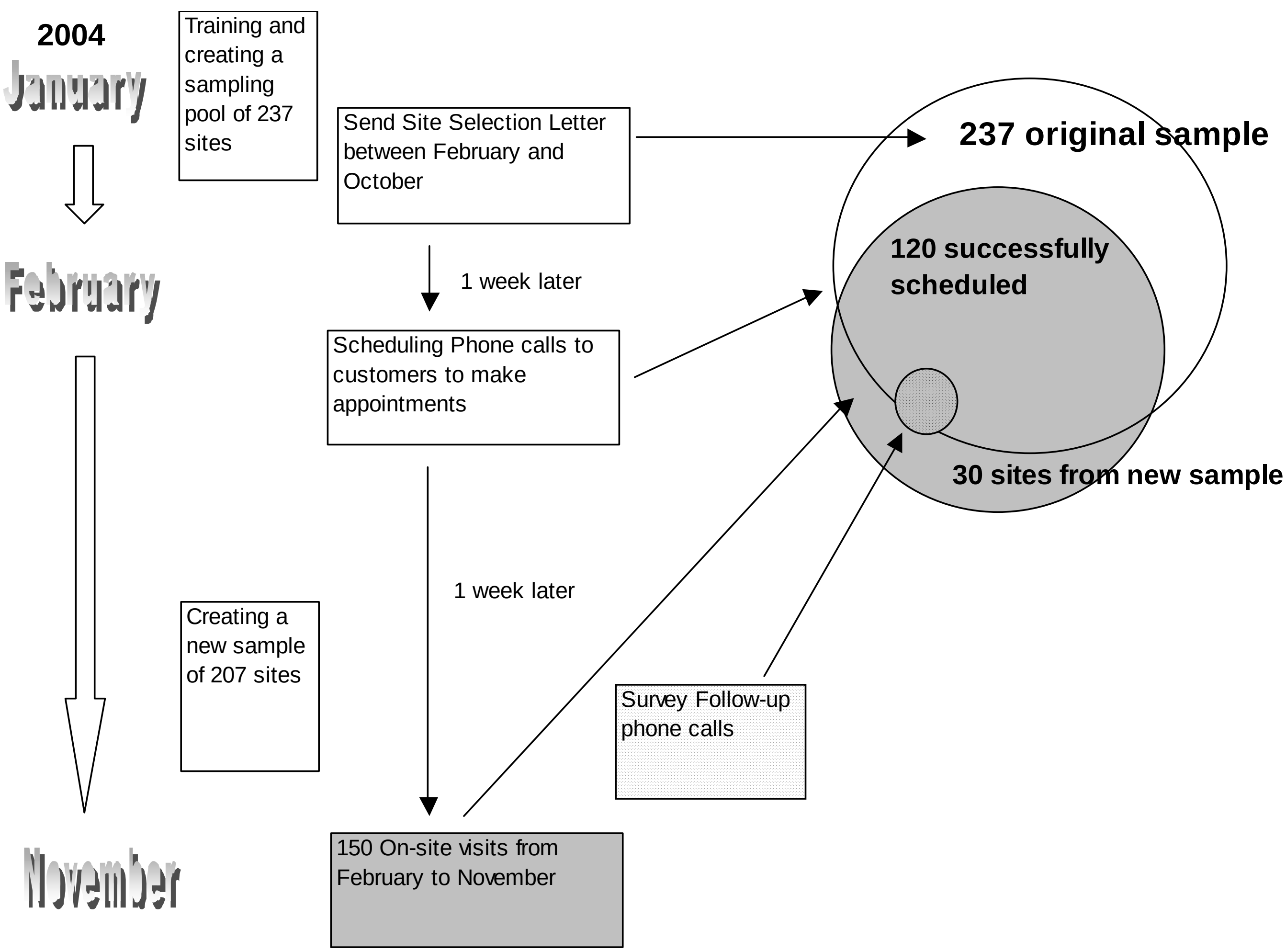
[34] One respondent was unsatisfied because he did not think the Commission has "converted" enough homeowners.

APPENDIX A: CUSTOMER COMMUNICATIONS MATERIALS AND TIMELINE

Customers were first contacted by a pre-verification package that included a selection letter, a survey, and a fun facts sheet about PV systems. (samples included in this appendix.) While on site, they were presented with a verifier identification letter. For customers that could not be contacted by phone, a door hanger was left on their door to request them to contact the verifier in their area.

Figure A-1 summarizes the timeline and all the communications between the contract team and the ERP program participants.

Figure A-1
Customer Communication Flow Chart



Sample Selection Letter

«Date»

«Name»
«Address»
«City», «State» «Zip»

Dear «Salutation»:

Congratulations on the purchase and installation of your renewable energy electric generation system. As you know, a portion of your system cost was funded through a rebate from the Energy Commission's Emerging Renewables Program. The Commission periodically conducts site visits to collect important survey information from program participants and to verify the type of equipment installed. You have been selected to participate in an on-site verification survey. The Energy Commission's contractor, KEMA-XENERGY Inc., will be contacting you soon to set up an appointment for the site visit.

Site visits represent one element of the program requirements as specified in the Commission's program guidebook. As the technical consultant under contract to the Energy Commission, KEMA-XENERGY, Inc. personnel will be accessing your system on a clear weather day to assure that it is operating during their visit.

During the on-site visit, the surveyor will gather and confirm information about your installed renewable energy system including equipment type, system configuration, and other key information. The surveyor will also perform a brief check of the system performance and, with your permission, take a few photographs of the system to provide a visual record of the installation. The visit should take less than one hour.

With this letter you will find a Customer Survey, an important part of this research on renewable energy systems in California. Please take a few moments to fill it out and return it in the enclosed postage paid envelope.

Thank you for your personal commitment to clean and reliable renewable energy. Please feel free to contact me at (916) 653-2834 or by E-mail at dtrensch@energy.state.ca.us if you have any questions about this process.

Sincerely yours,
Dale Trenschel, Lead

Sample Customer Survey

CALIFORNIA ENERGY COMMISSION

Emerging Renewables Program Residential Survey

We need your help!

Please take 10-15 minutes to complete this survey.

The California Energy Commission is surveying customers who have installed a photovoltaic (i.e., solar cell or PV) or small wind system funded in part by the Energy Commission's Emerging Renewables Program. The purpose of this survey is to better understand the current markets for these emerging renewable technologies, to accelerate the opening of these markets in California, and to improve the program.

- All of your answers will be kept strictly confidential.
- If you do not know the answer, please leave the question blank.
- Please feel free to add comments on any blank spaces on the survey.

Your participation supports renewable energy research in California.

Please return the completed survey in the enclosed postage paid envelope:

California Energy Commission
Emerging Renewables Survey Processing Center
492 Ninth Street, Suite 220
Oakland, California 94607-9990

1. Who in your family or business decided to install your system?
   [1]o Me
   [2]o Spouse/Partner
   [3]o Other ____

Renewable Energy System

2. Have your PV panels been cleaned (in the dry season)?
   [1]o Yes, and I plan on cleaning the panels every ________ months.
   [2]o No, but I plan on cleaning the panels every ________ months.
   [3]o No, I don't plan to clean the panels.

3. What is the approximate date of system installation?
   [1]o ______________ [9]o Don't know

4. On what approximate date did the system begin operation?
   [1]o ______________ [9]o Don't know

5. Did you obtain an estimate of typical **annual energy production** for your system prior to its installation?
   [1]o Yes → The estimate was ________________kWh/Year
   → Where did you obtain this information?
   [a]o Vendor/ Installer
   [b]o California Energy Commission website
   [c]o Other source:__________________
   [2]o No

Economics

6. How did you pay for your system?

   [1]o 100% Cash

   [2]o Leased

   [3]o Financed → % of total financed? ____________%

   #Years? ____________Years

   Interest Rate? ____________%

   What type of financing did you use?

   Mortgage loan

   Personal loan

   Other (please specify)

7. What was the total system cost?

   [1]o ______________ [9]o Don't know

8. What did you expect the payback of your renewable energy investment to be?

   (Payback is the number of years it takes before your electric bill savings equal the cost of the system to you)

   [1]o Less than 2 years [2]o 2 to 5 years

   [3]o 5 to 10 years [4]o 10 to 15 years

   [5]o 15 to 25 years [6]o 25 or more years

   [9]o Don't know

   [99]o Payback was not factor in my purchase

9. How likely is it that you would have installed the renewable system had you…

   a. Received no rebate?

   [1]o Not at all likely

   [2]o Somewhat likely

[3]o Very likely

[9]o Don't know

b. Received half of your rebate?

[1]o Not at all likely

[2]o Somewhat likely

[3]o Very likely

[9]o Don't know

10. On average, what do you estimate your renewable energy system is saving you on your monthly electricity bill?

$________ per month

11. Are the savings on your monthly ELECTRIC bill higher, lower or about the same as you expected?

[1]o Higher [2]o Lower

[3]o Same [9]o Don't Know

Comments:

____

____

12. When installing the renewable energy system, did you consider implementing any other electricity bill-reduction strategies?

[1]o Yes → What were the strategies?

[1]o Energy-efficiency improvements (i.e., new lighting, appliances, etc.)

[2]o Conservation (i.e., turn off lights, change thermostat settings)

[3]o Other ___________________

[2]o No

13. If you did invest in energy efficiency, what did you do (check all that apply)?

1o Lighting upgrade (CFL lightbulbs)	2o Window upgrade
3o Insulation	4o Efficient air conditioner
5o Efficient electric water heater	6o Other efficient appliances
7o Other efficiency investments ____________________	9o Don't know

14. Did you participate in any utility/state programs that provided incentives for energy efficiency measures?

1o Yes → Which program(s)? ____________________

2o No

15. How satisfied are you with your energy-efficiency investments or programs?

1o Not at all satisfied

2o Somewhat satisfied

3o Very satisfied

9o Don't know

16. Did you change your electricity usage since the installation of the renewable energy system?

1o Yes →

1o Installed new equipment (e.g., Jacuzzi) ____________________

2o Replaced existing equipment with a new efficient model ______________

3o Removed equipment ______________________________

4o Conservation

5o Other: ______________________________

2o No

9o Don't know

17. Was your renewable energy system installation part of any other upgrades, remodeling, or retrofits to your home or business?

[1]o Yes [2]o No

Decision Process

18. What were your primary reasons for wanting to purchase and use renewable energy technology? (Check all that apply AND circle the most important.)

[1]o Reduce electricity bills

[2]o Improve the overall reliability of my electricity supply

[3]o Concern for the environment

[4]o Become independent of my electric utility

[5]o Promote/test new technology

[6]o Other: ____

19. What sources did you use to: (Check all that apply AND circle the most important.)

	Learn about the Emerging Renewables Program	Select your system	Select your dealer/ vendor	Select your installer
Other renewable users	[1]o	[1]o	[1]o	[1]o
Dealer/vendor	[2]o	[2]o	[2]o	[2]o
Print advertisements	[3]o	[3]o	[3]o	[3]o
Magazine or newspaper articles	[4]o	[4]o	[4]o	[4]o
California Energy Commission website (www.consumerenergycenter.org)	[7]o	[7]o	[7]o	[7]o
Other Internet Site	[8]o	[8]o	[8]o	[8]o
Other (please describe):	[99]o	[99]o	[99]o	[99]o

____

____

20. Are you aware of "net metering" electricity rates in California?

[1]o Yes → Are you taking advantage of the net metering rate benefits offered by your utility?

[a]o Yes

[b]o No → Why not? ____

____

[c]o Don't know

[2]o No

[9]o Don't know

Program and Installation Experience

21. How difficult was it for you to get your system up and running?

[1]o Not at all difficult

[2]o Somewhat difficult

[3]o Very difficult

[9]o Don't know

22. Regarding the **selection, design, installation, and operation** of your system, have you experienced challenges finding or dealing with any of the following:

a.	The appropriate sizing, performance or cost of the system	Yes	No
b.	A suitable vendor	Yes	No
c.	Financing for installation	Yes	No
d.	Information about renewable energy incentives	Yes	No
e.	Information about economic and financial benefits	Yes	No
f.	Building permits	Yes	No
g.	Installation	Yes	No
h.	Operation (energy production or power output)	Yes	No
i.	Maintenance	Yes	No

23. If you had the opportunity to purchase your renewable energy generation system all over again, would you?

[1]o Yes [2]o No

Why or why not?

____

____

24. What would you change (or like to have changed) about the purchase process?

____

____

25. Would you recommend this type of system to others?

[1]o Yes → How many people have you recommended it to? ________

[2]o No

Why or why not?

____

____

26. Where would you send people for information on renewables? (Check all that apply.)

[1]o California Energy Commission
1-800-555-7794, renewable@energy.state.ca.us, or
http://www.consumerenergycenter.org/erprebate/

[2]o Contractor

[3]o Magazine or trade journal

[4]o Other Internet Site

____

[9]o Not applicable. Reason: ______________________________

27. On a scale of 1 to 5, with 1 meaning "Not at all likely" and 5 meaning "Extremely likely," under the following circumstances how likely would you be to consider purchasing or leasing ADDITIONAL renewable energy generation equipment?

		Not at all likely……. Extremely likely				
a.	It was (or equipment was) more widely available	1	2	3	4	5
b.	Same as a. less expensive	1	2	3	4	5
c.	The equipment were more reliable	1	2	3	4	5
d.	If the energy resource were more reliable	1	2	3	4	5
e.	They (equipment) were more commonly used by others	1	2	3	4	5
f.	It was easier to find out about them	1	2	3	4	5
g.	If a supplier would take all responsibility for operation and maintenance of the unit	1	2	3	4	5
h.	It was easier to obtain long-term financing for the investment at reasonable rates	1	2	3	4	5
i.	Regulatory permitting process were simpler	1	2	3	4	5
j.	If the energy system were less costly to operate and maintain	1	2	3	4	5
k.	If the renewable energy system did not require as much space within my home (or on my property)	1	2	3	4	5
l.	Reduce rebate application processing time	1	2	3	4	5

[1]o Other: ______________________________________

[2]o My energy needs are already completely satisfied

28. Have you found the Emerging Renewables Program easy to understand and participate in?

[1]o Yes

[2]o No, Why or why not?

____

____

29. Who did you work with to install your renewable energy system? (Check all that apply.)

[1]o Dealer/Vendor [2]o Installer

[3]o Self-Installed [4]o Other ______________________

30. Did the installer/dealer suggest any of the following in your discussions about purchasing your renewable energy system? (Check all that apply.)

[1]o Energy savings/ conservation ideas

[2]o Including batteries in your system

[9]o None

31. Overall, on a scale from 1 to 5, with 1 meaning "Not at all satisfied" and 5 meaning "Extremely satisfied," how satisfied were you with:

Not at all satisfied……………. Extremely satisfied

a.	Your vendor/distributor/installer	1	2	3	4	5
b.	Your rebate amount	1	2	3	4	5
c.	Your rebate program participation experience	1	2	3	4	5
d.	Your rebate application process	1	2	3	4	5
e.	The time it took to receive your rebate	1	2	3	4	5
f.	Your electric bill savings	1	2	3	4	5
g.	The California Energy Commission	1	2	3	4	5
h.	The equipment you purchased and its performance	1	2	3	4	5

32. Did your vendor/installer handle the communications and paperwork for you with the any or all of the following entities? (Check all that apply.)

[1]o Energy Commission

[2]o Utility

[3]o Permitting Office

33. What are the benefits you have received from participating in the Emerging Renewables Program? (Check all that apply AND circle the most important.)

[1]o Lower utility bill, saved money
[2]o Home/equipment is more energy efficient, uses less energy
[3]o Improve the environment
[4]o Other ____
[9]o Don't know

General Questions

34. What is your age?

[1]o under 24	[2]o 25 to 34
[3]o 35 to 44	[4]o 45 to 54
[5]o 55 to 64	[6]o 65 or older

35. What is your gender?

[1]o Male [2]o Female

36. How many people, including yourself, usually live in this household or work at this business? ______

37. What is the approximate square footage of your home or commercial building?

____

38. Do you rent or own your residence or commercial building?

[1]o Rent [2]o Own

39. What is the approximate age of your home or commercial building? _______ years

40. What is the approximate market value of your home or commercial building?
    - [1]o $250,000 or less
    - [2]o $250,000 to $500,000
    - [3]o $500,000 to $750,000
    - [4]o $750,000 to $1,000,000
    - [5]o more than $1,000,000

For more information, please check the Consumer Energy Center website:
www.consumerenergycenter.org/erprebate/

Thank you very much for your time and thoughtful input.

Would you like to receive a copy of the survey results?

Yes___

No___

NAME: _________________________________

STREET ADDRESS:_________________________________

CITY, CA ZIP:_________________________________

Sample Fun Facts Sheet

Some interesting (and useful) facts about photovoltaic systems.

For more information, go to www.consumerenergycenter.org.

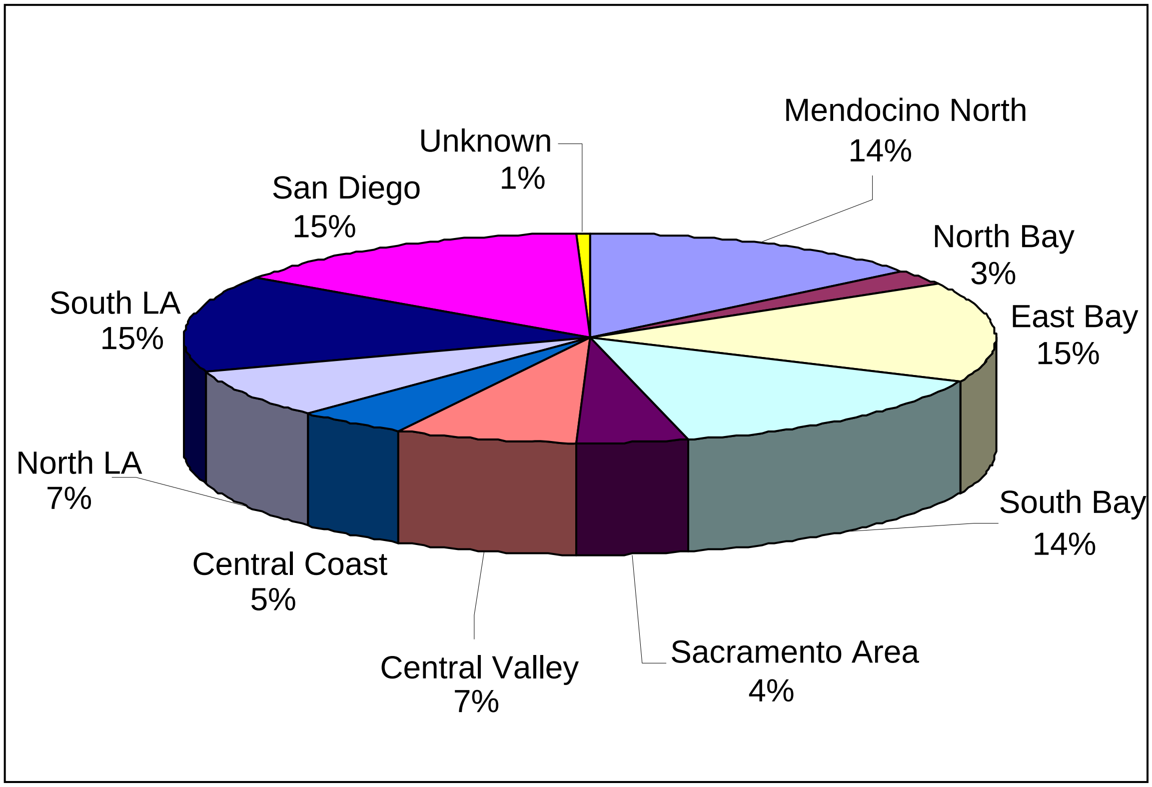
Did You Know…?

- There are over 50,000 kW of solar photovoltaic systems in California. That’s equivalent to a small conventional power plant.
- Your system’s efficiency could be improved by about 7 percent if you wash off the dust that builds up on it during the dry season.
- A single small "hard shadow" covering one cell on a PV module can reduce the output of that module by 50 percent (watch those vent stacks!).
- In the last 20 years, solar modules have decreased in price by about 70 percent.
- In the last 20 years, DC to AC inverters have increased their efficiencies by about 30 percent.
- Grid-tied renewable electricity systems reduce both conventional power generation and stress on electricity distribution lines.
- In California, the local property tax assessor cannot increase your property tax by the value of an installed renewable energy system.
- Over its lifetime, a typical photovoltaic module will produce 12 times the amount of energy it took to manufacture it.
- Over 30 states now have some form of net metering law. California was one of the first.
- Over 7,000 renewable energy systems have been installed on homes and businesses in California under the California Energy Commission's incentive program.

APPENDIX B: SAMPLING METHODOLOGY

In November, 2003, a sample of sites having received a rebate from the Energy Commission was extracted from the Emerging Renewables Program (ERP) database. At that time, almost 7,000 systems had been installed using ERP rebate funds in California; 97 percent of them were photovoltaic systems. The systems were located throughout California, with over 50 percent under the PG&E territory. **Figure B-1** shows the geographic distribution of the population.

Figure B-1
Distribution of Population by Geographic Regions (Total=6925)



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A verification sample was extracted based on installer categories to best fit the verification objective: to detect fraud and investigate whether fraud or lower quality installations are more prominent in one installer group versus another. Moreover, since some installers are geographically specific, a random sample of installers would also give us a random sample of geographic regions and utilities territories.

This population was represented by four categories of installers: self-install/unknown installer and commercial installers who have installed 1-4 sites, 5-19 sites and 20 or more sites. Almost 70 percent of the systems were installed by one of the 72 large or 131 medium commercial installers even though the combination of large and medium commercial installers only represent 11 percent of all installers in the population. Owner installed or unknown installers made up 18 percent (1,211 sites). This category of installer represents 61 percent of all installers in the population. **Table B-1** shows the distribution of installers in the population.

Table B-1
Population by Installer Type

Installer Category	Population	Installers		Sites	
		#	%	#	%
1	Self-install + unknown	1,211	61%	1,211	18%
2	1-4 commercial installers	572	29%	869	13%
3	5-19 commercial installers	131	7%	1,238	18%
4	20+ commercial installers	72	4%	3,459	51%
Total		**1,986**	**100%**	**6,777**	**100%**

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On-site verification efforts revealed that some of the owner-installed or unknown installers sites were actually commercially installed sites or vice versa. The on-site results presented under Section 2 and 3 are based on this new information.

Original Sample

A sample of 237 sites was selected from the database population of 6,925 records in November, 2003. This original sample had two components: pre-selected sites specified by the program manager and random sites from a targeted sample frame. The sample allocation shows the total number of targeted sites to be completed by installer category. The site selection renders a total number of sites to extract from the population in order to fulfill the allocation targets.

A total of 40 pre-selected sites were allocated to the sample. There were 23 individual sites and seven sets of installers/retailers that were pre-selected to be included in the sample. The set of 23 individual pre-selected sites were categorized as A sites, the sites associated with the six pre-selected installers as B sites, and the sites associated with the pre-selected retailer as C sites. Four of the pre-selected A sites were ultimately excluded because they were sampled by a prior study. The 19 remaining A sites were allocated to the sample as were 18 B sites (3 per installer) and three C sites (three per the one retailer). **Table B-2** shows the sample allocation of the pre-selected sites.

Table B-2
Sample Allocation of Pre-selected sites Categories

Installer Category	Sample Allocation	A	B		C	Total Sites
		Sites	Installers	Sites	Sites	
1	Self-install + unknown	3	0	0	3	6
2	1-4 commercial installers	2	0	0	0	2
3	5-19 commercial installers	2	1	3	0	5
4	20+ commercial installers	12	5	15	0	27
Total		**19**	**6**	**18**	**3**	**40**

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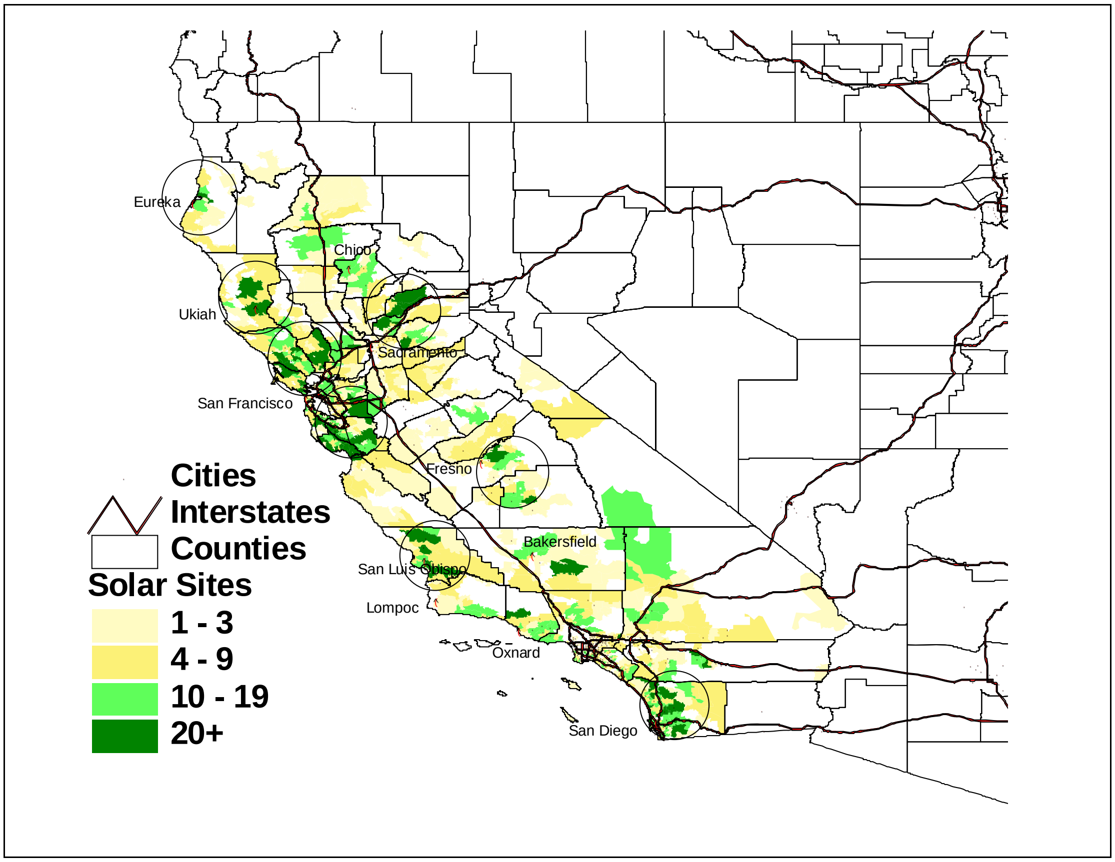
After obtaining the pre-selected site requirements, the sampling approach was developed to maximize the efficiency and effectiveness of the 150 on-site surveys, examine Program Guidebook compliance and system performance. First, the sample frame was limited to eight geographic clusters throughout the state to create survey efficiencies while still ensuring coverage across the state. **Figure B-2** shows the eight clusters: Eureka, Ukiah, Northern San Francisco Bay Area, Southern San Francisco Bay Area, San Luis Obispo, Fresno and San Diego.

Next, 141 sites that were sampled by prior studies were removed, as were the pre-selected sites, all the sites associated with the six pre-selected installers and the pre-selected retailer, and all category 3 or 4 installers if less than five installations were located in the eight geographic clusters.

Figure B-2
Map of Clusters, Shaded by Number of Solar Sites per Zip Code



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The final sample frame, as shown in **Table B-3**, included 4,018 sites, representing 1,294 installers. The sample frame includes 59 percent of the population of sites and 66 percent of installers. Similar to the population, the sample frame shows that Category 1, self-installers and unknown, represents the majority (64 percent) of the installers; however, medium and large commercial installers, those with five or more sites installed in the geographical cluster targeted, installed the majority (67 percent) of the systems.

Table B-3
Sample Frame

Installer Category	Population	Installers #	Installers %	Sites #	Sites %
1	Self-install + unknown	829	64%	809	21%
2	1-4 commercial installers	335	26%	492	12%
3	5-19 commercial installers	78	6%	697	17%
4	20+ commercial installers	52	4%	2,000	50%
Total		**1,294**	**100%**	**4,018**	**100%**

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The remaining 110 sites to be verified were allocated across three categories of installations within the targeted geographic clusters: self-installers or unknown, commercial installers with 5-19 installed sites and commercial installers with more than 20 sites. Sites associated with small commercial installers (those who had installed 1-4 sites) were excluded. By excluding this category of installers, the sample included 19-20 installers from each of the three remaining installer categories: one site for each targeted self-installer and three sites for each of the targeted medium and large commercial installers.

The self-installer sample allowed for comparison with commercial installers. The medium and large commercial samples allowed for an assessment of compliance for the 38 installers sampled, and allowed for an assessment of performance across installer categories. The small commercial installer category could not be meaningfully assessed with the small sample size of this project due to its breadth (over 500 installers) and the inability to sample several sites per installer (most small commercial installers installed only one or two sites). **Table B-4** shows the number of sites and installers allotted to each of our targeted installer category.

Table B-4
Sample Allocation of the Random Sample

Installer Category	Sample Allocation	Random Sites	Random Installers
1	Self-install + unknown	14	14
2	1-4 commercial installers	0	0
3	5-19 commercial installers	54	18
4	20+ commercial installers	42	14
Total		**110**	**46**

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The total sample allocation included 40 pre-selected sites and 110 randomly selected sites as summarized in **Table B-5** below. In addition, the number of wind sites and the number of sites installed prior to July 2002 were limited to five and 35 respectively.

Table B-5
Total Sample Allocation

Installer Category	Sample Allocation	Sites	Installers
1	Self-install + unknown	20	20
2	1-4 commercial installers	2	0
3	5-19 commercial installers	59	19
4	20+ commercial installers	69	19
Total		**150**	**58**

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In order to meet the sample allocation targets, a sample pool of 237 sites was created. The sample pool is the selection of sites from which the surveyors scheduled verification visits. For category 1 installers, the sample pool totaled 31 sites, with a target of 20 completes. For category 3 and 4 installers, the sample pool included five sites for each installer and aimed to verify three sites per installer. (The two type-2 sites are pre-selected A sites.)

Table B-6 shows the sample pool, excluding pre-selected sites. For type 1 sites, 23 sites were randomly drawn from the sample frame. For type 3 and 4 installers, 18 and 14 installers from the sample frame, respectively, were drawn from the sample frame, with five sites drawn per installer.

Table B-6
Sample Pool (Excluding Pre-Selected Sites)

Installer Category	Sample Selection	Random Sites	Random Installers
1	Self-install + unknown	23	23
2	1-4 commercial installers	0	0
3	5-19 commercial installers	90	18
4	20+ commercial installers	70	14
Total		**183**	**55**

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Table B-7 shows the total sample selection, including pre-selected sites and installers. A total of 237 sites were selected into the original sample pool. Note that wind sites and sites with installations prior to July 2002 were limited to nine and 50 sites, respectively.

Table B-7
Complete Sample Pool

Installer Category	Sample Allocation	Random Sites	Random Installers
1	Self-install + unknown	31	31
2	1-4 commercial installers	2	2
3	5-19 commercial installers	97	19
4	20+ commercial installers	107	19
Total		**237**	**71**

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Second Sample

At the end of August 2004, 120 sites were completed from our original sample pool leaving 31 sites to be scheduled.[1] The sample pool was nearly depleted due to a higher proportion of unreachable customer than anticipated. Also in August, the ERP project manger requested that KEMA-XENERGY investigate sites installed by a particular installer. To complete the verification work, a second sample was selected to expand the number of sites per installer in the original sample pool and to add new installers (including the one specified by the ERP project manager).

Since some of the installers targeted in the original sample fell short of meeting the goal of three sites per installer, the new sample aimed to expand the original sample to fulfill the three sites goal for the original sampled installers. **Table B-8** shows the number of sites needed by the original sampled installers and number that were fulfilled by expanding the original sample.

Table B-8
Number of Sites Completed by Expanded Sample
(Before Adding New Installers)

Category	Installer ID	Sites Needed	Fulfilled by Expanded Sample
1	100 or 900	3	5
3	303	1	0
	304	1	1
	306	1	0
	308	1	0
	317	3	0
	319	1	0
	320	1	0
4	410	1	0
	411	1	1
	412	1	1
	415	3	0
	416	2	0
	418	1	0
	419	1	0
	420	1	0
A	1101	1	0
	1103	1	0
	1104	1	0
	1107	1	0
	1112	1	0
	1118	1	0
B	2205	1	1
Total		30	9

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After efforts to fulfill the sample requirement with additional sites for the original sampled installers, category 3 installers (medium-sized with 5-19 sites), category 4 installers (large-sized with over 20 sites) and category A installers (pre-selected) were still lacking; therefore, new installers were added in order to achieve the 150 verified site goal. **Table B-9** highlights the addition of 22 owner unknown installers, 13 random installers and the specific installer requested by the ERP project manager to the new sample.

Table B-9
Installers included in the New Sample

Category	Installer ID	Total New Sample	Fulfilled by expanded sample	Fulfilled by new installers	Total completed
1	100/900	22	5		6
3	301	4			
	303	6			
	304	3	1		1
	309	7		1	1
	315	8		1	1
	319	1			
4	322	8			
	401	3			
	403	5		2	2
	404	1			
	405	2		1	1
	407	17			
	409	17		3	3
	411	9	1		1
	412	4	1		1
	413	16		4	4
	414	1			
	412	6		3	3
	423	46		2	2
B	2200	20		12	12
	2205	1	1	0	1
Total		207	9	29	38

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Thereafter, 38 sites were verified from this new list of installers to conclude all on-site activities. The eight additional sites were limited access sites from the pre-selected installer. **Table B-10** below summarizes the distribution of the 30 completed sites under the new sample plan.

Table B-10
Sites Completed Under the New Sample Plan

	Needed		**Second sample**		**Fulfilled**
Category	**Installers**	**Sites**	**Installers**	**Sites**	**Sites**
1	3	3	22	22	5
2	0	0	0	0	0
3	7	9	6	29	3
4	8	11	13	135	17
A	6	6	0	0	0
B	1	1	2	21	5
C	0	0	0	0	0
Total	**25**	**30**	**43**	**207**	**30**

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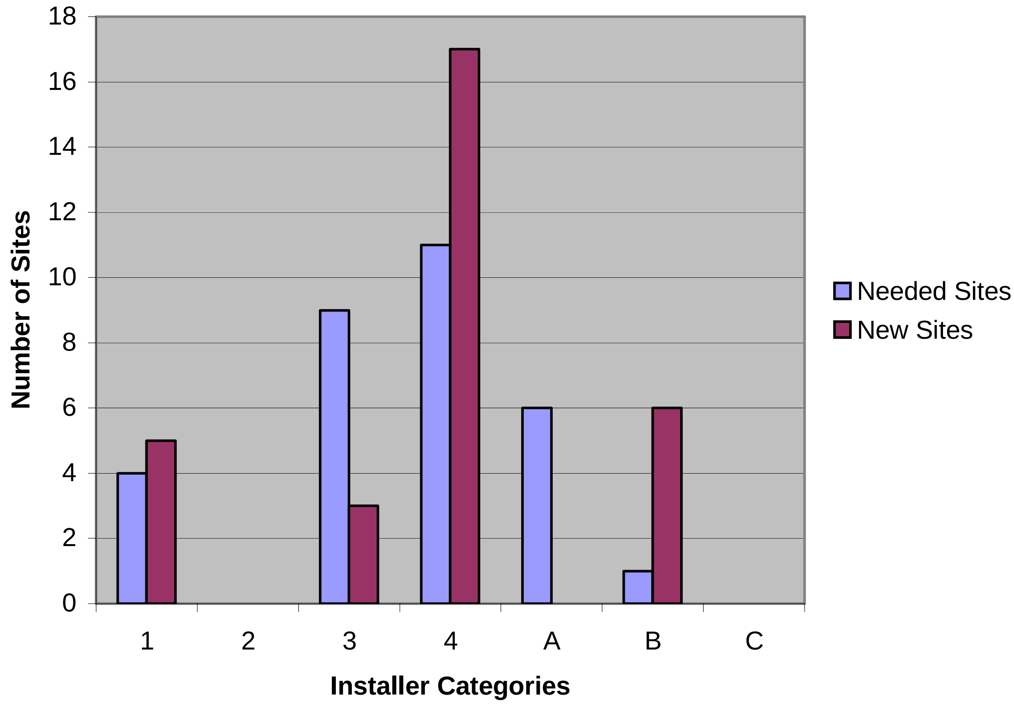
The sites completed under the new sample have a slight bias towards Type 4 installers that are more widely represented in the Bay Area. Also, due to the addition of the specific installer requested by the ERP project manager, the sample goal from the failed-to-schedule Type A sites (unique sites picked by the ERP project manager) were shifted to Type B (unique installers picked by the project manager). **Figure B-1** illustrates the deviations from the original sample plan. The list of new installers added to the original sample is shown in **Figure B-3**.

Figure B-3
Distribution of Sites Completed under New Sample



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[1] At the end of August, 125 sites were completed, including 5 sites that were not from our original sample pool (4 training sites and 1 site from installer 2205). These sites were not taken from our original sample pool but did fulfill our sample plan. For the purpose of discussion in this section, these 5 sites are grouped under the second sample.

APPENDIX C: SCHEDULING PROTOCOL AND RESULTS

In advance of a verification visit, a verifier or scheduler called the customer responsible for a targeted site one week in advance to make an appointment. In most cases, the customer would have already received an official site selection letter and a customer satisfaction survey by mail. The schedulers followed a scheduling protocol to determine whether the site could be feasibly scheduled. For example, a site might not be scheduled if the verifier needed to make an extra trip to a remote location for a single visit.

In general, those customers contacted by phone were enthusiastic about a verification visit and were very cooperative. A few customers were suspicious of the role of the verifier and called the KEMA-XENERGY office to verify their identity. Only a few cases occurred where the customer expressed reluctance in agreeing to a site visit. In those cases, our verifiers drove by their properties for an unscheduled, limited access verification.

As discussed in Appendix B Sampling Methodology, 120 of the 237 of the originally sampled sites were successfully scheduled. While scheduling for site visits, two common problems arose: telephone numbers in the database were incorrect/outdated or unavailable. In some cases, customers' current phone numbers were successfully acquired through public resources[1]; however, this process increased scheduling time.

For every site, the project team tried to schedule an appointment at least four times. Other common issues encountered while scheduling that prevented a verification visit included:

- Customer did not answer the phone;
- Customer did not respond to voice mail;
- Customer was not available when contact was made via phone;
- Customer declined a site visit, for example, due to vacation.

Additionally, a few customers had specific circumstances that prevented verification appointments. For example, one renewable energy system purchaser was about to move and had already removed his system to be reinstalled at his new residence.[2] On another occasion, the original purchaser of the system had passed away and his spouse declined a site visit.

In two cases, the purchasers registered on the ERP database were housing developers who later sold the properties to different owners. The only telephone numbers available were that of the housing developers and they were not authorized to provide their clients' phone number. Public resources were first used to update the contact information; when that failed, limited access visits were conducted on those sites for basic verifications. For some of the housing developer's sites, the project team tested leaving door hangers at the customer sites with the verifier's contact information to solicit customer callbacks. However, none of these customers called back.

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[1] Public resources used include phone books, Yahoo! Directory and the Ultimate White Pages.

[2] The new address was recorded and the project team later verified on a phone call that the system was reinstalled and passed the utility's inspection.